SWITCHING BEHAVIOUR AND SITUATION TRANSITION WITHIN THE CONTEXT OF AN OPERANT ANALYSIS OF SELF CONTROL

A dissertation submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Psychology in the University of Canterbury

by

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ERRATA

Abstract	lines 9/10	".....results were inconclusive, but switching and food key responding were equally sensitive measures of preference."
page 91	line 1	figure 17
	line 9	figure 18
page 93	line 7	"..... exponent of perfect matching....."

ACKNOWLEDGEMENTS

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ABSTRACT

In concurrent schedules of reinforcement relative response allocation or time allocation is often used as a measure of preference. In the present study response allocation to a switching key was developed as an alternative measure of preference for concurrently available food key stimuli. In experiment 1 the switching response was placed on a variable interval schedule of 30 seconds and proved to be a more sensitive measure of preference than food key responding. Experiment 2 investigated the effect of systematically varying the food key and switching key schedules; results were inconclusive, but switching performance remained the more sensitive measure of preference. In experiment 3 preferences for components of a multiple food key schedule were investigated but the switching key performance was at best only an ordinal indicator of preference. In experiment 4 switching key performance was more sensitive to reinforcement duration than was food key performance. The concluding experiment investigated switching performance as an indicator of preference for small frequent rewards versus large delayed rewards. The subjects' preferences for small frequent reward were modified by rewarding switching into large delayed food schedules and by punishing switching into small frequent food schedules. Results were discussed within the context of an operant analysis of self control.

CHAPTER 1

INTRODUCTION

The choice between a large delayed reward and a smaller immediate one has received much attention in psychological research. Rachlin (1974) viewed the selection of a large delayed reward as evidence of "self control" while Ainslie (1975) regarded selection of a small immediate reward as an indication of "impulsiveness".

An experimental paradigm for investigating preferences places an organism into a situation where it can switch between differing conditions of reinforcement. Preference may then be measured by response allocation (Catania 1969) or by the time allocated to stimuli signalling the differential reinforcement contingencies (Baum and Rachlin 1969) but few studies have studied the process of switching between stimuli as an explicitly defined and measurable response.

A series of experiments by Findley (1958) resulted in a switching or changeover procedure which has since been used extensively in studies of preference with minimal departures from the original paradigm. The present study sought to augment Findley's original procedure (described on page 7) and use it to investigate conditions under which the behaviour described by Rachlin as "self control" could itself be controlled. That is the behaviour of exhibiting preference for a large delayed reward instead of a smaller more immediate one.

SELF CONTROL

Concepts such as the soul, the psyche, instincts, mind and the self have been regarded as the pilots of individual behaviour in intrapsychic personality theories (Maddi 1968, Levy 1970).

Dualistic theories of behaviour had been challenged by Mach 1914, who advocated the replacement of causality by the establishment of functional relationships between elements or variables. Kantor 1922, 1924, 1969a, 1969b, also argued against the use of metaphysical abstractions in explanations of behaviour. Influenced by the philosophy of science advocated by Mach and Kantor, the publications of B.F. Skinner 1938, 1953, 1957a, 1963, 1964 and Ferster and Skinner 1957, established a branch of psychology known as the experimental analysis of behaviour. In an experimental analysis of behaviour, psychological private events and subjective experience were to be considered as no more private, than the process of digestion or the interbehaviour of hydrogen and oxygen to make H_2O (Observer 1973).

The issues of self control were discussed by Skinner 1953, who postulated a relationship between controlled and controlling responses. While the controlled response may be less accessible to the effects of environmental variables, its probability of occurrence remains influenced by the identified controlling response which is in turn more accessible to environmental contingencies.

> "The controlling response may manipulate any of the variables of which the controlled response is a function; hence there are a good many different forms of self control."
>
> (Skinner 1953, page 23].)

Human behaviour change through self control has been extensively researched (Lefcourt 1966, Bandura 1971, Goldfried and Merbaum 1973, Kanfer and Karoly 1973). Gewirtz 1971 challenged the implied necessity of anomalous hyphenated-reinforcement phenomena such as 'vicarious' and 'self-reinforcement' effects, claiming that failure to discover extrinsic sources of reinforcement was no reason to postulate new constructs.

Infrahuman studies of self control have been less extensive but developed along similar lines. An assumption that organisms naturally choose immediate and effortless food reinforcement was questioned by Neuringer (1969, 1970) who trained pigeons to peck a response disc for access to grain while food was freely available in the experimental chamber. Implications of Neuringer's findings for self management have yet to be explored although the assumption that a large freely available food reward is synonymous with reinforcement, is a deviation from the philosophical basis of the experimental analysis of behaviour. It should be noted that Neuringer did not relate his findings to the self control issue but instead contradicted the view that deprivation is a prerequisite for effective reinforcement.

Animal analogues of self reinforcement were used by Mahoney and Bandura (1972) who trained pigeons to peck at a lighted disc, gradually introduced the food dispenser earlier, then withdrew the source of food when the animal chose to eat instead of pecking the disc first. Withdrawal of the food dispenser as a punishment for 'transgressions' eventually resulted in over one hundred successful trials without transgressions. A follow up study by Bandura and Mahoney (1974) trained pigeons in this form of 'self reward' and tested the adherence to work requirements under decreasing likelihood of punishment for unmerited self reward. The durability of the behaviour was limited, as successful transgressions led to reduced adherence to self reinforcement. In another study by Mahoney, Bandura, Dirks and Wright (1973), monkeys demonstrated a preference for self reward although the transgression problem was not resolved. The transgression or contract problem was described by Premack and Anglin (1973) as one of self denial, resolved only temporarily by punishment for transgressions.

Mahoney and Bandura's concepts of reward and punishment are placed in jeopardy when the operational definition of reinforcement as a consequence which increases the frequency or probability of a response reoccurring, is used. The issue is then one of defining the relationship between high and low probability behaviours and predicting the outcomes as the variables are systematically altered (Premack, 1959).

Rachlin and Green (1972) retained the operant view of self control in an experiment which studied the conditions under which pigeons would commit themselves to a large delayed reward in preference to a small immediate one. When presented with a concurrent choice, pigeons invariably preferred the stimuli indicating more immediate reinforcement but when required to commit themselves to either, a choice, or no choice plus inevitable larger delayed reinforcement, the commitment was to the latter. The degree of commitment was a function of its temporal proximity to the choice point, leading Rachlin and Green to redefine the study of self control in terms of a shift, of the cause of behaviour from short term to long term events, thus supporting the contention of Staddon (1973) that the causes of behaviour should not be limited merely to temporally contiguous stimuli.

> "To say that the origin of self control is not in the self, is not to say that the organism has no properties or been subtracted out of consideration. What has been subtracted out are those psychological (as opposed to biological) properties of the organism such as memory, expectancy, response strength etc., which serve only to bridge temporal gaps."
>
> (Rachlin, 1974, page 99.)

Rachlin insists that by taking the temporal view, the construct of 'self' is hypothetical and redundant. Ainslie (1975) developed the temporal theme into a behavioural theory of impulsiveness and impulse control while Deluty (1978) extended the model to include aversive events.

In Deluty's model the pigeon exhibited a reversal of preference for a large delayed punishment as the time between commitment and choice increased. The smaller more immediate punishment was preferred as the commitment response had less immediate consequences.

Catania (1975) commented on the critical distinction between reinforcing oneself and reinforcing a response. In ordinary reinforcement, the presence of food serves as a discriminative stimulus controlling the organism's approach to the feeder but in self reinforcement this cannot be the case. In Catania's view the relevant demonstration of extinction of such a consummatory response should therefore be based on reinforcement terminated by the pigeon rather than by the experimenter. It follows that the important relation is the one that exists between the two responses of initiation and termination (viz. Skinner's controlled and controlling response), rather than the one that exists between either response and the primary reinforcer.

Rachlin and Green (1972) derived a model which provides for a relation to be described between two alternatives:

$$\frac{V_1}{V_2} = \frac{A_1}{A_2} \times \frac{D_2}{D_1}$$

(where V represents the value of the choice, A represents the amount of food and D represents the delay to reinforcement).
Rachlin and Green maintained $\frac{A_1}{A_2}$ at .50 and varied the delay to reinforcement. Thus when D_2 was 4 seconds and D_1 was zero (immediate reinforcement) then $\frac{V_1}{V_2} = .5 \times \frac{4}{0}$ = infinity at the choice point (X), predicting that the smaller immediate reinforcement would be chosen.

At a point Y, 10 seconds prior to X then $\frac{V_1}{V_2} = \frac{.5(4+10)}{(0+10)} = 0.7$ predicting that the large reward would be chosen.

A prediction of $\frac{V_1}{V_2}$ and therefore of potential control, can be made using only observable and measurable variables. Contending that self control is a 'now versus later' issue, Rachlin (1974) dismisses the spatial

locus of control (from inside versus outside the skin), as the term self control seems to imply and adopts the temporal locus by asking, 'How far away from the present must we look to find the source of control?' (Rachlin 1974, page 95).

The question of self control is thus stated as, "under what conditions will an organism choose a large delayed reward in preference to a small more immediate one?"

CHOICE

In studies of choice where concurrent schedules are used, the major dependent variables are usually the rates of responding on two operanda, frequently expressed as the rate on one as a proportion of the overall rate on both. The behaviour of switching from one operandum to another is not explicitly recorded as no specified topography is required for the type of analysis usually sought. The main thrust of research on the actual switching response in concurrent schedules has been a concern to prevent superstitious reinforcement of switching by interposing a changeover delay (Herrnstein 1961, Shull and Pliskoff 1967, Guilkey, Shull and Brownstein 1975). The changeover delay (COD) prevents primary reinforcement immediately after a switch, even though a reinforcement on the food key may be scheduled. In concurrent procedures where the two schedules operate independently, the high probability that a reinforcement is set up while the organism responds on the alternative key, increases the chance that switching per se would be reinforced by food rather than by the change from one discriminative stimulus to another.

The concern of Herrnstein and others has been with responses in the presence of stimuli during which differential reinforcement opportunities were scheduled, without the specious effects of primary reinforcement immediately following switching behaviour. Most experiments have therefore used a COD as a matter of routine to minimise temporal contiguity between switching behaviour and subsequent reinforcement.

While the elimination of extraneous sources of control is a sound and accepted practice in the experimental analysis of behaviour, the extraneous sources themselves are frequently the beginning points for fruitful investigation. Sidman (1960) argues that because switching behaviour is an inevitable component of concurrent procedures, then gaining experimental control over its sources of reinforcement is essential.

> 'The understanding and control of such normally unrecorded behaviour and of its participation in unprogrammed contingencies is vital to the study of complex multiple-response situations.'
> (Sidman, 1960, page 365.)

SWITCHING

In Findley's original 1958 study the topography of switching was made explicit and accessible to investigation. Pigeons pecked a main key on which were programmed two independent schedules of food reinforcement, each correlated with a different key colour. Single pecks on another key, the switching key, changed the colour and associated schedule on the food key. The Findley procedure and the two key procedure (e.g. Herrnstein, 1961; Catania, 1963) have been regarded as essentially equivalent in studies of choice behaviour, with the focus of the analysis on main key responding and little attention paid to switching behaviour.

Switching to preferred conditions has been investigated using the two-key concurrent-chains procedure (Autor, 1969; Fantino, 1969a; 1969b; Squires and Fantino, 1971; Navarick and Fantino, 1976). In the concurrent-chains procedure two keys are used and the subject's responses in an initial link provide a measure of preference for one

or other of the terminal link stimuli. Although concurrent-chains are useful for studying choice, the emphasis again is on the responses on two operanda and not on the actual switch between stimuli. Using concurrent-chains schedules Baum (1974) viewed reinforcement as a process of situation transition, a transition which the present study sought to explicitly define in terms of Findley's switching or changeover response.

It was reasoned that if the behaviour of transferring from one situation to another proved responsive to traditional experimental manipulation then switching behaviour might play a role as significant as the initial link behaviour in concurrent-chains schedules. The advance response discussed by Honig, Beale, Seraganian, Lander and Muir (1972) is a corrollary of Findley's changeover response and was used to study inhibitory control. It was described as, "a bit of instrumental behaviour and as such is under the control of stimuli, subject to motivating conditions and sensitive to its consequences." (Honig et al., 1972, page 61.) In discussing its nature, maintenance and applications Honig et al. suggested that the advance response could be used to investigate problems which could not normally be attacked with more traditional techniques.

Within the context of the operant self control paradigm, the switch between opportunities for large delayed or small immediate rewards is a critical response. In Rachlin and Green's model the switch occurs prior to the choice and removes one of the alternatives. The commitment thus made removes one of the sources of primary reinforcement. A recurring problem encountered in the natural environment is that even when such a commitment is made it frequently fails to change a choice situation into a no choice one. When the two initial choices remain available the making of a prior commitment is no longer a controlling response, or at best a rather weak one.

Presumably the control exerted by the commitment weakens as the time between it and the actual choice increases, exemplified in human terms by the alcoholic or chronic smoker who cannot resist when faced with opportunities to indulge, in spite of previous verbal declarations resembling commitment. Because it is therefore necessary to seek the sources of reinforcement for maintaining a commitment when an organism is at the same time faced with a choice, the present study sought to investigate the sources of control when choice and commitment were concurrently available.

THE SWITCHING PROCEDURE

A few studies have placed the switching response on a fixed ratio (FR) schedule where alternation of the food key stimulus occurs only after a specified number of responses on the switching key. Findley (1958) found that fixed ratios could be used to alter the preference for a given colour on the food key. As the ratio requirement to switch out of a food key signal increased, the probability of remaining in the presence of that signal increased. Stubbs and Pliskoff (1969) altered the changeover ratio to FR20 and noted a sharp decrease in the changeover key response rate. Guilkey, Shull aand Brownstein (1975) used FR2 on a switching key and noted the effect on the food key response rate, while Stubbs, Pliskoff and Reid (1977) discussed the effect on changeover behaviour of changeover consequences and relative reinforcement rate, raising the possibility that changeover rate could be related to the overall reinforcement rate on the food key. This was supported by Tustin and Davison (1979) in a study where fixed interval and variable interval schedules were used on the changeover or switching key. In this study the results indicated that molar measures of changeover performance were

useful but of the two experiments where a changeover schedule was used, "neither experiment unequivocally supported an attempt to describe changeover performance as a function of the ratio of the reinforcement rates". (Tustin and Davison, 1979, page 87). In another study (White, 1979) using rats as subjects and chain pulling as the switching response, a decrease in switching response rate occurred with an increase in the ratio needed to change.

The main emphasis has therefore been a consideration of the effects of varying the switching ratio on the local response rates at the food producing operandum rather than on rates at the switching operandum.

Generally the first switching response has rendered the food key inoperative until the switching ratio has been completed (Findley, 1958; Stubbs and Pliskoff, 1969; White, 1979). The first switching response has therefore been an irreversible commitment and placed the organism into a situation similar to the initial link of a chain where there is a choice of either primary reinforcement or no reinforcement. That is, to gain access to food, the switching ratio had to be completed and in other cases the switching key was inoperative until prerequisites had been met on the food key (Shull and Pliskoff, 1967; Shull and Pliskoff, 1971).

Stubbs and Pliskoff (1969) in comparing the effects of changeover rate with those of a COD said "Whether the changeover requirement is a procedural factor more useful than the COD remains to be determined" (page 894). In order to determine the usefulness of changeover or switching requirements, the present study retained a COD of two seconds and investigated the effects of concurrent food key schedules while switching behaviour itself was exposed to variable interval schedules. Apart from the COD, the three schedules, two on the food key and one on the switching key were otherwise independent.

The first response on the switching key did not render the food key inoperative and responses on the food key had no programmed consequences for the switching schedule.

The matching relationship in concurrent schedules is well documented (Herrnstein 1961, de Villiers and Herrnstein 1976, de Villiers 1977, Staddon and Motheral 1978) and states in its most basic form that the relative rate of responding in a concurrent schedule matches the relative rate of reinforcement in that schedule. The generalised matching law was developed by Baum (1974b) to provide measures of sensitivity and bias. In Baum's equation ratios are used instead of proportions and the functions are expressed as $\log \frac{B_1}{B_2} = a \log \frac{R_1}{R_2} + \log k$, where B is the frequency of the response, R is the obtained frequency of reinforcement, and the subscripts 1 and 2 refer to the concurrently available schedules. With perfect matching a and k are equal to 1.0. If a as the measure of sensitivity is less than 1.0 the subjects have undermatched and if more than 1.0 the behaviour is termed overmatching. If k = 1 then its logarithm is zero which indicates that bias between the two conditions 1 and 2 does not exist. Deviations in the value of k indicate that more of the behaviour under investigation has been allocated to one or the other conditions.

Data obtained from the present study were presented according to Baum's equation, or:

$$\log \frac{B_2}{B_1} = a \log \frac{R_1}{R_2} + b$$

where B is the frequency of response on the switching key. R is the obtained rate of reinforcement, 1 and 2 refer to the food key schedules in green and red respectively and b is the measure of bias. Evidence suggests that the relationship is molar rather than molecular in that it is an overriding psychological principle rather than a descriptive statistic (Nevin 1969, Nevin 1979, Heyman 1979). However, Shimp (1966)

and Silberberg, Hamilton, Ziriax and Casey (1978) prefer the molecular view. If the psychological principle of the molar hypothesis applies to switching behaviour itself then the relative frequency of response on the switching key should conform to the contingencies of reinforcement obtained on the food key.

DEPENDENT AND INDEPENDENT VARIABLES

In matching experiments the obtained frequency rather than the programmed frequency of reinforcement is commonly used as the independent variable. Thus the independent variable is to some extent dependent on the subject's behaviour (Rachlin 1971, de Villiers and Herrnstein 1976). This variation stemming from the correlation based law of effect (Baum 1973) was criticised by Zeiler (1977) who said, 'To assert a causal relation between the two variables of response rate and reinforcer frequency attributes causality to correlation - such assertions are hazardous at best'. (Zeiler 1977, page 32.) The fact of relative reinforcement frequencies both determining and depending on the relative response frequencies has inherent tautological implications which are appropriate for developing mathematical models, so in the present study, emphasis was placed on the relation between switching behaviour and obtained reinforcement although consideration was given to the relation between switching behaviour and programmed reinforcement.

The consequence of responding on the switching key was entry to the alternative food key schedules (or exit from the current food key schedule) while the consequence of responding on the food key was primary reinforcement. The immediate reinforcement for switching behaviour was therefore seen as the appearance of a new food key colour. It was thought that the ratio of responding on the switching key might provide a measure of preference for the food key stimuli regardless of the actual obtained

reinforcements. Thus the functions obtained were calculated in terms of obtained and of scheduled reinforcements.

The variables considered were rate of reinforcement, rate of responding on the switching key and to a lesser extent rate of responding on the food key. As reinforcement schedules were continuously and independently operating the time base for all response rates was the same - the overall length of each session. Therefore relative frequencies of responding and of reinforcements were used as the basic measures of interest.

CHAPTER 2

EXPERIMENT 1: SWITCHING ON A VI30 SCHEDULE

In experiments where a subject switches between stimulus situations only one response is usually required for the change, e.g. Findley 1958, Baum and Rachlin 1969, Todorov 1971. In the experimental analysis of behaviour a single response followed by an immediate consequence is equivalent to a fixed ratio of one (FR1) and leaves little opportunity for using rate of response as the basic dimension for analysis. By arranging intermittent delivery of consequences, so that the organism responds a number of times before receiving reinforcement, then frequency or rate of responding becomes a viable dependent variable as a rate dimension is more easily measured than the probability of a single response. In the experimental analysis of behaviour a common method of arranging intermittant consequences is the use of a variable interval schedule. In variable interval schedules the first response after a specified time has elapsed, is reinforced. Although the inter-reinforcement intervals vary, the average minimum time between reinforcement availability is constant and specified in the schedule. Thus a variable interval schedule with 60 seconds as the mean inter-reinforcement time is indicated by the symbols VI60. In the present study all schedules were variable intervals and all time parameters refer to seconds. In Experiment 1 the switching response was placed on a variable interval schedule of 30 seconds (VI30) to determine whether the subsequent switching behaviour was a useful parameter for prediction and control. Its utility depended on the extent to which the relative rate of responding on the switching key matched the relative rate of reinforcement obtained on the concurrent schedules of the food key.

METHOD

Subjects. Four experimentally naive homing pigeons, M5, M6, M7 and M8, were maintained on a diet of grain and pigeon peas at 80% plus or minus 15 grams of their free feeding body weight. Grit and water were freely available in the home cages.

Apparatus. The experimental enclosure was a standard Grason-Stadler animal chest, model 33125 AA. The response mechanisms were two translucent keys of 20 mm diameter transilluminated by lights from multi-stimulus projectors behind the keys. A force of 17 grams was necessary to operate the microswitch behind each key.

Reinforcement was access to grain for 4 seconds from a magazine located 152 mm below the food (centre) key. The switching key was 10 cm to the right of the food key. A third key to the left was unlit and inoperative.

During reinforcement the key lights were off and the magazine illuminated by a white light. A houselight was on during magazine training and shaping of key pecks, but was gradually faded out through the initial training and in sessions when data were collected only the key lights were illuminated between reinforcements. The chamber was housed in a sound insulating box, a fan provided ventilation and white noise was present to mask extraneous noises.

Reinforcements and other events were controlled automatically by standard tape pullers and electromechanical relays in an adjoining room, in which all relevant events were recorded on counters, timers and a cumulative recorder. Relevant events were responses on the two keys, changeovers, reinforcements and duration of food key colours.

Procedure. Each session ended when 40 reinforcements had been obtained. Pecks on the centre or food key resulted in grain presentation according to two concurrent VI schedules, each associated with a different colour on the food key. The colours on the food key were either red or green and could be changed by a single peck on the white switching key.

To expose the pigeons to the alternative food key schedules the red and green colours were initially alternated every 30 seconds by the experimenter as well as changing whenever a switching peck occurred. To induce pecks on the switching key the food key was darkened until a switching peck occurred (Honig et al. 1972). When consistent responding was established on both keys the automatic alternation of colours and darkening of the food key was discontinued.

The requirements on the switching key for a food key colour change were gradually increased to conform to a VI30 schedule. Thus the first switching response after a mean interval of 30 seconds changed the food key colour, initiated a COD on the food key preventing reinforcement for two seconds and turned off the switching key for two seconds.

The COD minimises superstitious reinforcement of switching key pecks and the two second blackout of the switching key prevented spurious data recording from response bursts. Exploratory studies had shown that without the immediate darkening of the switching key, bursts of responding in which a successful changeover occurred, continued for a brief period and were recorded as pecks in the presence of the new colour.

Experimental sessions were run daily for six days a week. After one adaptation session the animals were magazine trained and key peck responses to the food key were shaped and placed on a VI60 schedule.

All variable intervals were arranged on 10 interval constant probability schedules (Fleschler and Hoffman 1962). The concurrent schedules of reinforcement were varied according to the hyperbolic equation of Herrnstein 1967,

$$\frac{1}{x} + \frac{1}{y} = \frac{1}{c}$$

in which x is the mean inter-reinforcement interval in one key colour, y is the mean inter-reinforcement interval in the other key colour, and c is the combined mean interval for the two keys taken together. Note that these are the minimum mean intervals between reinforcements, not necessarily the actual mean intervals. In the present experiment the combined mean inter-reinforcement interval was 60 seconds. Experiment 1 began and ended with Conc. VI120 VI120 schedules in both green and red.

Except for the two seconds following a changeover the switching operandum was operative at any time, unlike Shull and Pliskoff's (1967) experiment where food key responses were prerequisites. As a result independence was maintained between food key concurrent schedules and between all food and switching key schedules except during reinforcements when all programming tapes and the two timers recording red or green key colour duration were stopped.

Variables. The main independent variable was the relative frequency of responding on the switching key calculated as the ratio of $\frac{B_2}{B_1}$, where B was the number of responses on the key, 2 indicated that the food key was red and 1 that the food key was green.

The other independent variable considered was the relative frequency of response on the food key calculated as the frequency of responses during green divided by the frequency of responses during red, or $\frac{F_1}{F_2}$ where F is the frequency of response and as before 1 indicates a green key colour and 2 the red key colour.

Note that the switching ratio is $\frac{B_2}{B_1}$ whereas the food key ratio is $\frac{F_1}{F_2}$ - the subscripts have been reversed to provide easier comparisons of switching and food key responding.

The dependent variable manipulated was the relative rate of reinforcement, or $\frac{R_1}{R_2}$, where R was the frequency of reinforcement and the subscripts were as above. Unless otherwise specified $\frac{R_1}{R_2}$ refers to obtained reinforcements rather than scheduled.

Steady State Criteria. Exposures to the schedules continued until the switching key proportions were stable. That is, rate in green divided by the total rate. A modification of Cummings and Schoenfield's (1960) steady state criteria was used. The first seven sessions were allowed for adjustment to the experimental conditions; thereafter the next six days' data were used to assess stability. The critical measure for each session was the mean relative response rate on the switching key. If the slope of the least squares regression line between all six days' measures was no more than one per hundred, the data were regarded as stable. That is, from the equation $y = ax+b$, the value of a was to be .01 or less. If a was greater than .01 another day's data was gathered and the stability of the last six sessions was again assessed.

If a slope of less than .01 occurred before twenty sessions, excluding the first seven adjustment sessions, then an added requirement was that no data point should be plus or minus .05 points from the mean proportion. In most cases the proportions stabilised before twenty sessions. Table 1 shows the exposures to the experimental conditions, the number of sessions in each phase and the slope of the last six proportions on the switching key. In summary; the specific manipulations were systematic changes in the programmed food key schedules while the switching key was held on a variable interval 30 second schedule.

Table 1. Response ratios on the switching key B_2/B_1 and the food key F_1/F_2 with obtained and scheduled reinforcement ratios. Steady state data are shown in the columns labelled sessions and slope. Data are taken from the last six sessions of each phase.

Pigeon	Phase	Food Key Schedule	Sessions	Slope	Ratios			
					Scheduled reinf.	Switching B_2/B_1	food key F_1/F_2	obtained reinf.
M5	I	conc. VI120 VI120	21	.005	1.0	1.54	1.14	1.05
	II	conc. VI180 VI90	17	.008	0.5	0.42	0.60	0.46
	III	conc. VI75 VI300	17	.000	4.0	6.24	4.33	3.90
	IV	conc. VI600 VI66.67	17	.009	0.111	0.15	0.19	0.10
	V	conc. VI120 VI120	28	.001	1.0	1.43	0.93	0.95
M6	I	conc. VI120 VI120	13	.001	1.0	1.09	0.99	0.97
	II	conc. VI180 VI90	28	.005	0.5	0.63	0.92	0.50
	III	conc. VI75 VI300	16	.003	4.0	4.10	2.66	3.80
	IV	conc. VI600 VI66.67	21	.009	0.11	0.18	0.27	0.17
	V	conc. VI120 VI120	16	.001	1.0	1.00	0.82	0.92
M7	I	conc. VI120 VI120	13	.006	1.0	1.19	0.84	1.00
	II	conc. VI180 VI90	18	.009	0.5	0.92	0.64	0.46
	III	conc. VI75 VI300	20	.004	4.0	2.54	2.27	3.62
	IV	conc. VI600 VI66.67	16	.001	0.111	0.22	0.34	0.12
	V	conc. VI120 VI120	22	.002	1.0	1.61	0.73	0.97
M8	I	conc. VI120 VI120	17	.005	1.0	1.22	0.89	0.91
	II	conc. VI180 VI90	18	.005	0.5	0.46	0.65	0.51
	III	conc. VI75 VI300	17	.001	4.0	3.25	2.90	3.14
	IV	conc. VI600 VI66.67	13	.003	0.111	0.10	0.12	0.09
	V	conc. VI120 VI120	22	.008	1.0	0.92	0.84	1.00

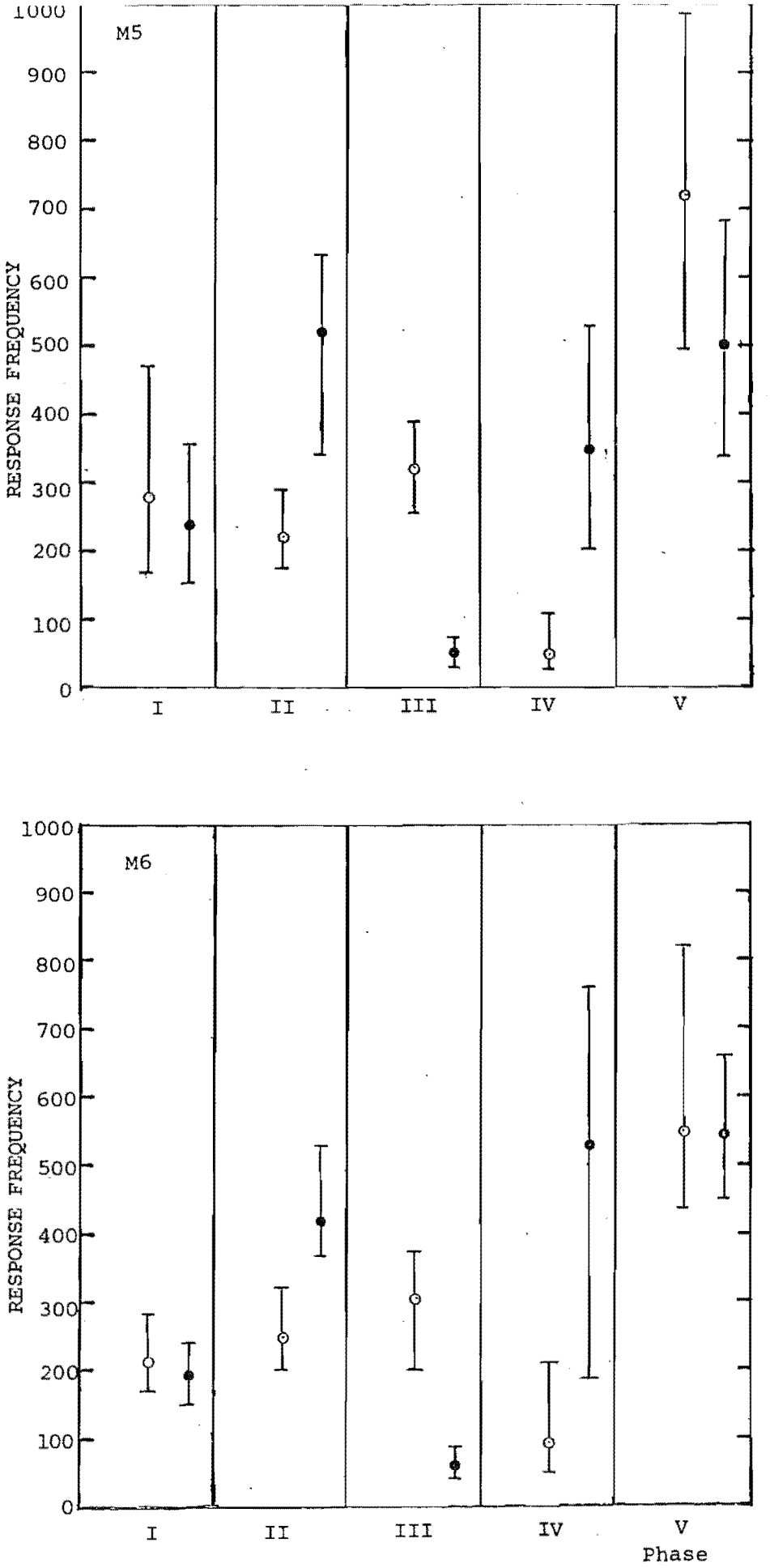


Fig. 1 Switching response frequency during the red key (open circles) and during the green key (closed circles). Data are the means and the range from the last six sessions of each phase.

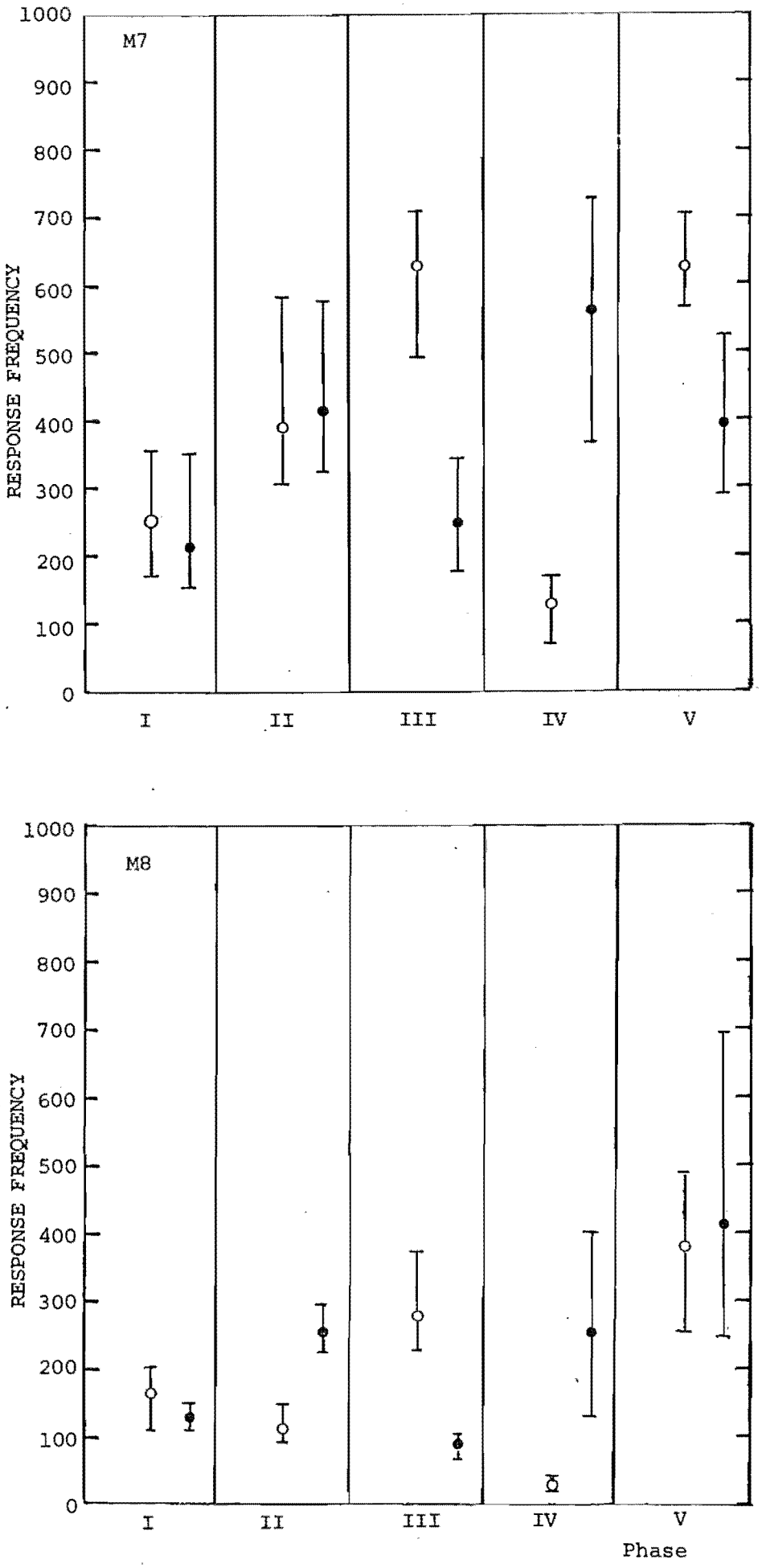


Fig. 2 Switching response frequency during the red key (open circles) and during the green key (closed circles). Data are the means and the ranges from the last six sessions of each phase.

RESULTS

The subjects responded with pecks at the food key interspersed with a lesser number of pecks at the switching key. Responding on both keys showed the even regular pattern typical of VI schedules. Post reinforcement pauses and response bursts were absent.

Table 1 shows the switching key ratios $\frac{B_2}{B_1}$ and the food key ratios $\frac{F_1}{F_2}$ together with the scheduled and obtained ratios of reinforcement. All data are from the last six sessions of each phase when switching behaviour was in a steady state. The switching ratios were derived from the B_2 and B_1 frequencies illustrated in Figures 1 and 2. B_2 is the frequency of responding on the white switching key while the food key was red and B_1 is the frequency on the switching key while the food key was green.

Although frequencies differ between the two baselines when a conc. VI120-VI120 food schedule was programmed, higher responding in phase V occurred on both keys and the $\frac{B_2}{B_1}$ ratios remained fairly consistent. The mean ratio was 1.2 with more responding at the red key by M5 and 7 and near indifference in M6 and M8.

In phase II as the less generous food schedule of VI180 was operating in green the frequency of B_1 rose sharply while in three out of four birds B_2 remained at baseline levels. The B_2 frequency of M7 rose with B_1 but remained slightly below producing a ratio of .92 compared with 1.19 in baseline. In phase III when the conc. VI75-VI30 schedules were in effect the B frequencies reversed and again more switching responses were evident in the presence of the less generous food schedule.

In phase IV with a conc. VI600-VI66.67 food schedule the $\frac{B_2}{B_1}$ ratio changed accordingly and more B responses occurred during the VI600 schedule.

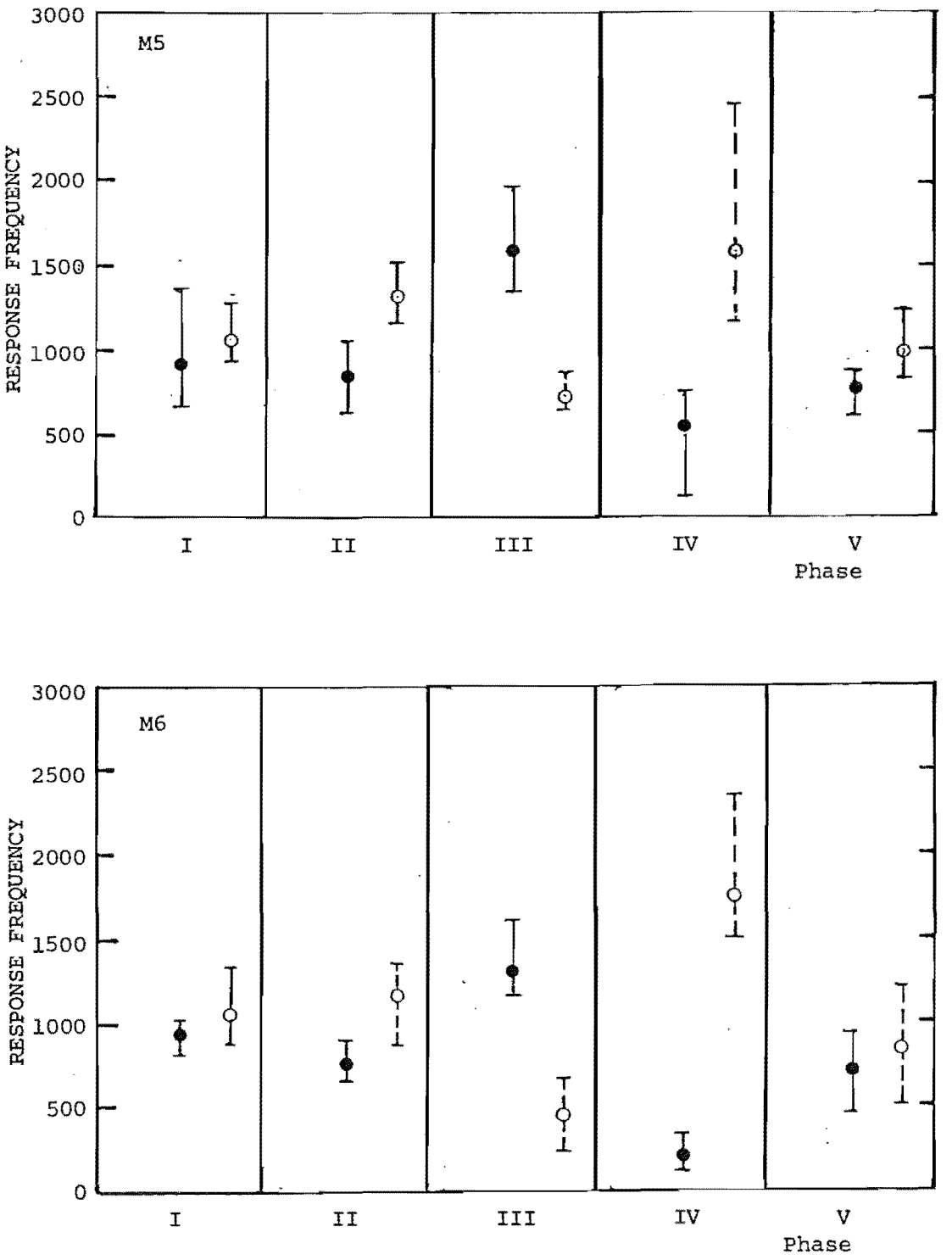


Fig. 3 Response frequency on the food key when the key was green (closed circles) and red (open circles). Data are the means and the ranges from the last six sessions of each phase.

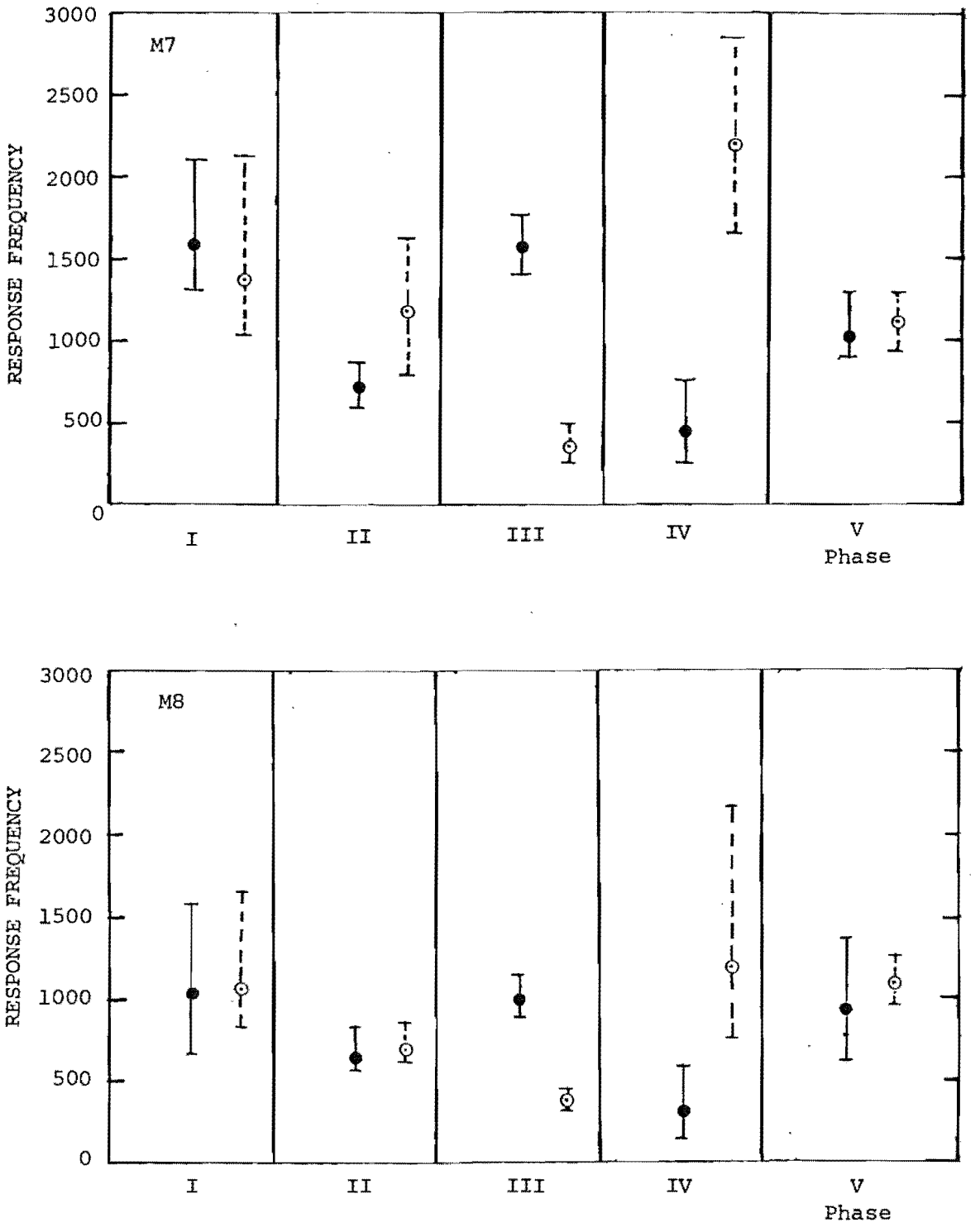
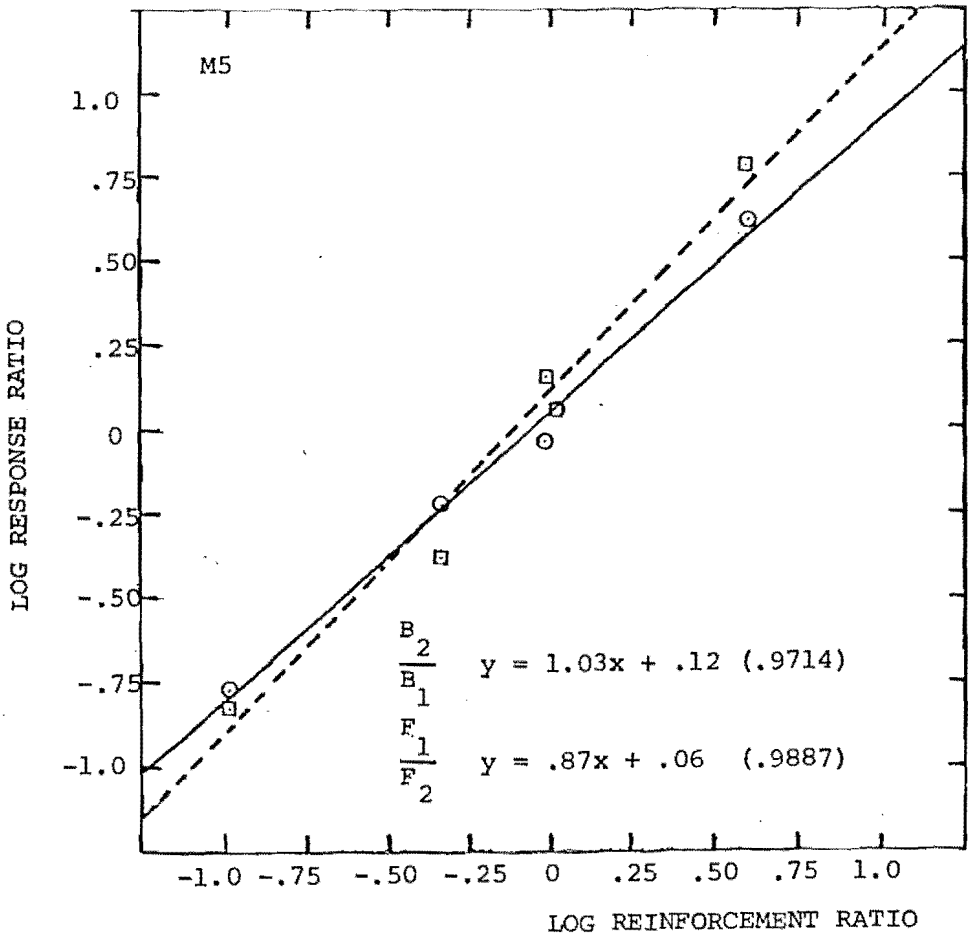


Fig. 4 Response frequency on the food key when the key was green (closed circles) and red (open circles). Data are the means and the ranges from the last six sessions of each phase.



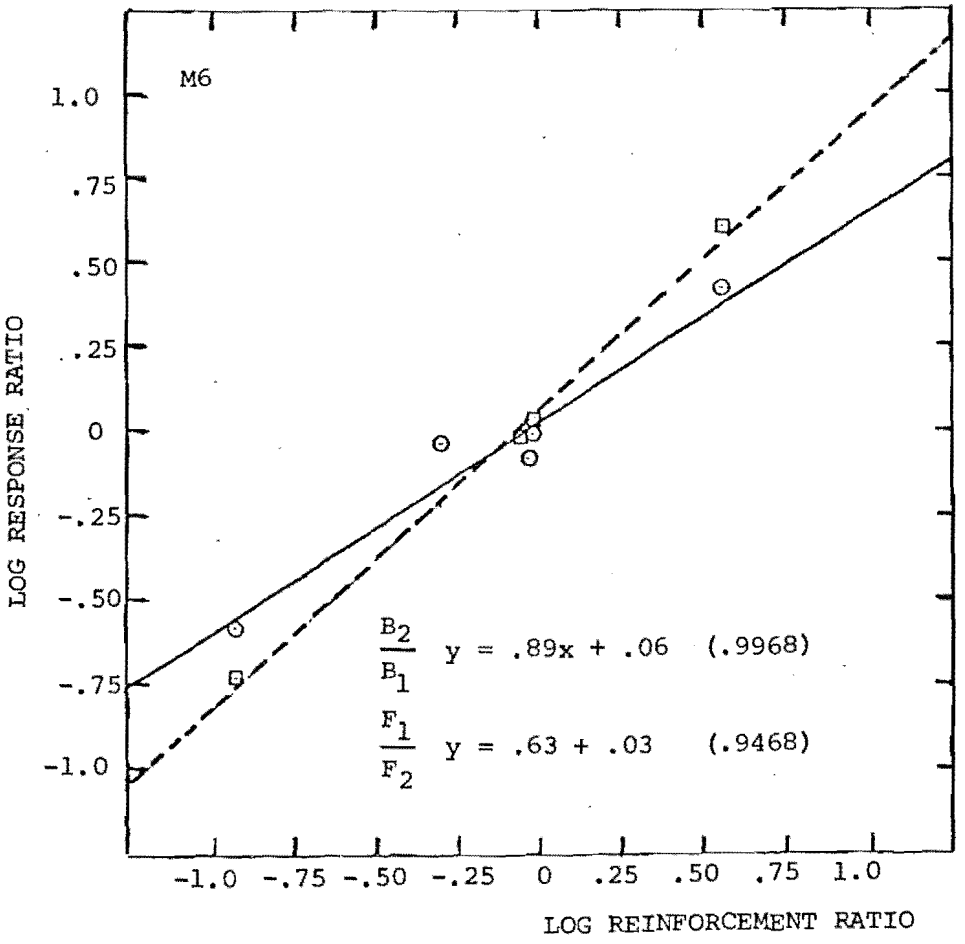
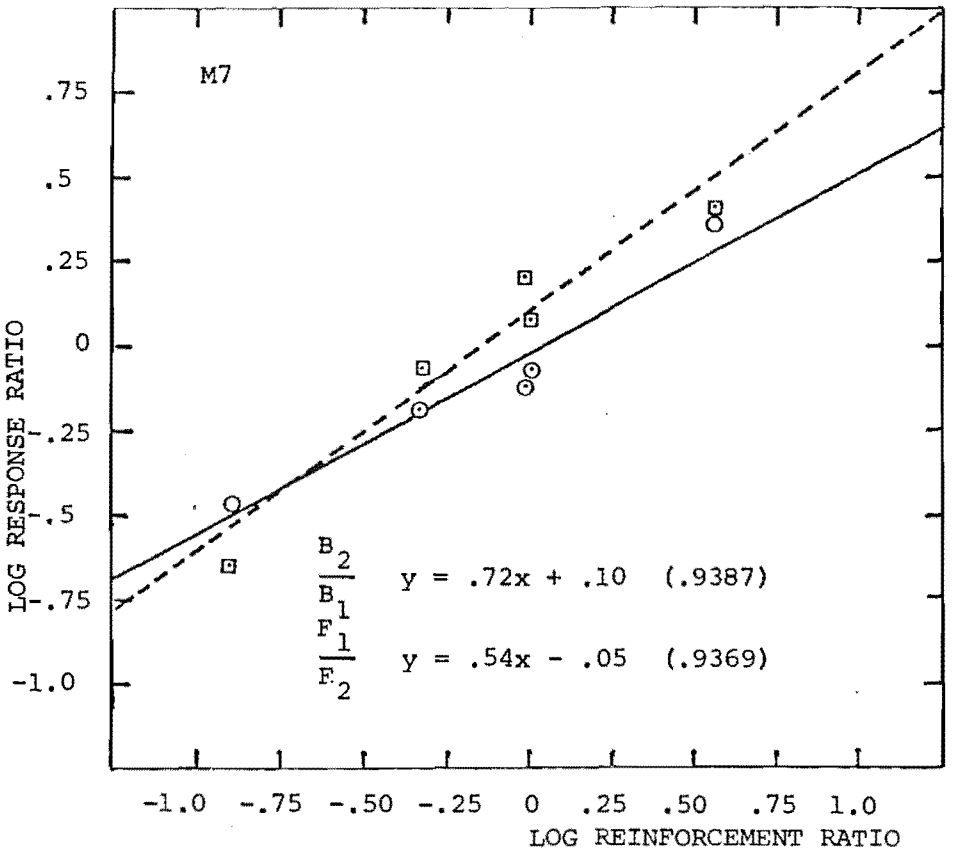


Fig. 5 Logarithms of response ratios as a function of log reinforcement ratios. Switching key functions B_2/B_1 are shown by squares and broken lines, food key functions F_1/F_2 by circles and solid lines Variance accounted for is shown in brackets.



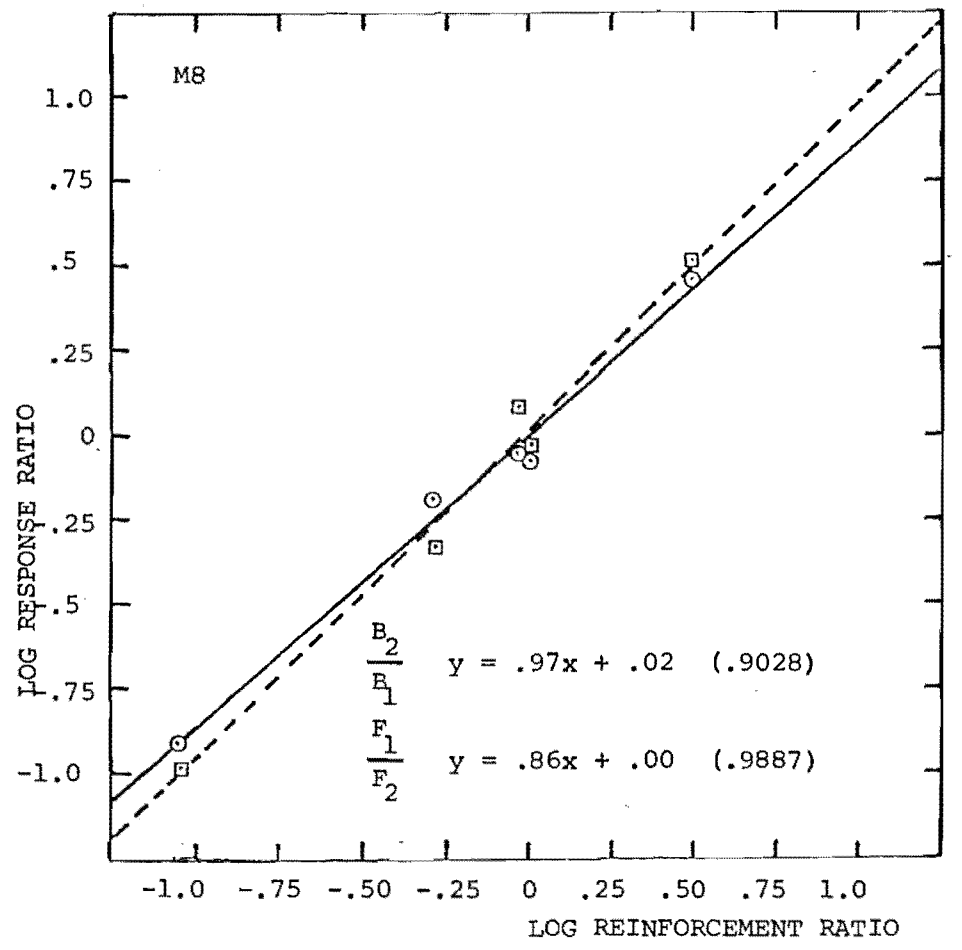


Fig. 6 Logarithms of response ratios as a function of log reinforcement ratios. Switching key functions B_1/B_2 are shown by squares and broken lines, food key functions F_1/F_2 by circles and solid lines. Variance accounted for is shown in brackets.

Figures 3 and 4 show the response frequencies and ranges at the food key. Frequencies F_1 and F_2 remained relatively stable for each subject between baselines of phase I and V. The mean $\frac{F_1}{F_2}$ ratio was .90, somewhat less than the switching ratio. In phase II when the green key was on a VI180 schedule $\frac{F_1}{F_2}$ decreased to a mean of .70 and rose to 3.04 in phase III when a conc. VI75-VI300 schedule was in effect. During phase IV when the green key schedule was an extreme VI600 the smallest $\frac{F_1}{F_2}$ ratios were evident with a mean of .23.

It is clear that responding on the switching key was faster when a less generous food schedule was operating and faster on the food key when a more generous schedule was in effect. To ascertain whether switching or food key responding provided a closer matching relationship to obtained reinforcement the regression functions were calculated and plotted logarithmically in figures 5 and 6. In figures 5 and 6 $\log \frac{B_2}{B_1}$ and $\frac{F_1}{F_2}$ are plotted on the same axes and it should be noted that the switching ratio is red/green while the food key ratio is green/red.

Responding on the food key shows undermatching with sensitivity measures for M5, M6, M7 and M8 of .87, .63, .54 and .86 respectively while the corresponding figures for switching were 1.03, .89, .72 and .97. In all four subjects the sensitivity of switching is higher than the sensitivity of food key responding (Table 2).

Table 2. The sensitivity (a) and bias (b) values for switching and food key responding for each subject.

Subject	B_2/B_1		F_1/F_2	
	a	b	a	b
M5	1.03	.02	.87	.06
M6	.89	.06	.63	.03
M7	.72	.10	.54	-.03
M8	.97	.02	.86	0.0

In all four subjects the b value is higher for the switching response showing a bias toward the green key colour. In all subjects the variance accounted for by the least squares line was above .90. These values are shown in brackets in Figures 5 and 6.

Results, especially on the food key, showing undermatching are in agreement with other research (Baum 1974a, Lobb & Davison 1975, Myers and Myers 1977 and Wearnden 1980).

On the switching key undermatching occurred in M6 and M7 although a values were well above those on the food key. M5 and M8 sensitivities were closer to 1.0 and again were higher than the corresponding values of a on the food key.

Reference to Figure 2 shows that M7 in phase II was close to indifference and showed a clear bias toward green in phase V. That is, $\frac{B_2}{B_1}$ was greater than 1.0 in the final baseline but close to a ratio of 1.0 (.92) during phase II when the scheduled reinforcement ratio was .50 and the obtained reinforcement ratio was .46.

It is usual in matching experiments to compare responding with obtained reinforcements as the reinforcements actually gained are regarded as the events which control the subject's behaviour. It may be argued that the events which control switching behaviour are the transitions to the alternative discriminative stimulus for food key responding. While food key responding is subject to direct primary reinforcement the temporal separation of switching from primary reinforcement is similar to that of chained schedules. In chained schedules animals must respond in an initial link before gaining access to a food schedule. It was reasoned that switching behaviour might more closely match the potential reinforcement rather than the actual reinforcement contingencies. In Table 3 the sensitivity and bias values of $\frac{B_2}{B_1}$ and $\frac{F_1}{F_2}$ are presented when scheduled rather than obtained $\frac{R_1}{R_2}$ was regarded as the independent variable.

Table 3. Sensitivity and bias values of switching and food key ratios with scheduled reinforcement ratios as the independent variable.

	B_2/B_1		F_1/F_2	
	a	b	a	b
M5	1.06	.10	.89	.05
M6	.86	.05	.61	.02
M7	.68	.09	.42	.04
M8	.97	.03	.86	-.03

Table 3 shows a similar pattern to table 2 with switching sensitivities higher than food key sensitivities. It would therefore be feasible to use either scheduled or obtained reinforcements as the independent variable. provided a close correlation existed between the two measures.

In the present experiment the correlation between obtained and scheduled reinforcement ratios was at least .99 for each subject. If however a large discrepancy between obtained and scheduled reinforcements existed the close matching relationship between switching and reinforcements could change.

Response Rate as a Variable. The results so far have used response frequencies to calculate the response ratios because responding on the switching schedules were regarded as essentially concurrent options. While the food schedules were concurrently and independently operating the switching schedule had some elements of a multiple schedule. Options to switch from red or green were not concurrently available and could only occur in sequence. If the presence of red and green are viewed as stimuli indicating distinct components with component durations specified largely by the experimenter as VI30 then the switching schedule may be regarded as a form of multiple schedule and the appropriate response measures should be $\frac{B_2}{T_2}$ and $\frac{B_1}{T_1}$ where T is the duration of the component and B the response frequencies. In experiment one the switching components alternated, the

key darkened for two seconds between components and the programming tape specified a minimum mean interval of 30 seconds. Table 4 shows the sensitivity and bias values when switching is analysed as a multiple VI30-VI30 schedule. Both scheduled and obtained reinforcements on the food key are considered together with the variance accounted for by the least squares function.

Table 4. Sensitivity and bias values for switching calculated as rate rather than frequency according to obtained and scheduled reinforcement on the food key. The variance accounted for by each function is shown.

	obtained reinforcement			scheduled reinforcement		
	a	b	variance	a	b	variance
M5	1.38	.14	.985	1.42	.02	.987
M6	1.20	.10	.990	1.16	.08	.987
M7	.81	.08	.974	.77	.06	.982
M8	1.36	.00	.994	1.37	-0.7	.982

The tendency is to overmatching with 'a' values at a mean of 1.19 in the obtained reinforcement column and 1.18 in the scheduled reinforcement column. The validity of the calculations in relating rate of response to frequency of reinforcement is admittedly questionable but offers possibilities for further research where matching might be achieved in multiple schedules.

Time as a Variable. Time allcoated to stimuli has been considered as an indication of preference by Baum and Rachlin (1969) and Honig et al. (1972). In experiment 1 the subjects responded consistently but at different rates on the switching key. Generally a changeover was made quickly after the VI30 schedule made one available and the allocation of time to either the red or green stimulus was constrained by the switching schedule. With only one response necessary to effect a changeover and with regular responding, the allocation of time to the food key stimuli should bear little relation to $\frac{R_1}{R_2}$.

Table 5. Sensitivity and bias values of Log $\frac{T_1}{T_2}$ as a function of Log $\frac{R_1}{R_2}$ and the variance accounted for by the least squares line.

Subject	a	b	VAC
M5	.37	.03	.372
M6	.31	.00	.675
M7	.10	-.03	.587
M8	.38	.02	.970

In table 5 it is seen that the sensitivity of time allocation calculated as time in green (T_1) divided by time in red (T_2) is low. All sensitivity values were below .4 and for M7 was .10. The variance accounted for by each equation varied from .372 to .970.

Because of the constraints exerted by the extended switching procedure the allocation of time to the food key stimuli is not, in the present study, regarded as a suitable variable.

Because the intermittent consequence of responding on the switching key was a change in the food key stimulus, it was conceivable that responding would be a function of the changeover rate. The single VI30 tape engendered a stable rate of response typical of variable interval schedules resulting in most cases in minimum variation in changeover rates.

Once a changeover opportunity had been set up by a single tape puller very little time elapsed before a successful switching response completed the circuit and changed the food key stimulus. However, typical changeover rates were below the two per minute possible with an overall mean of 1.74 per minute from green and 1.64 per minute from red (see appendix 1).

This indicates that the addition of a VI30 requirement to the switching response added a minimal constant to the mean inter-reinforcement interval scheduled in the red and green food key components and therefore was considered unlikely to contribute to the differences in response ratios to any significant extent.

DISCUSSION

Experiment 1 demonstrated that the extension of the normal single switching response to a rate dimension by placing it on a VI schedule has potential as a predictor of preference. Behaviour on the food key was similar to that obtained in conventional concurrent schedules with clear preferences but with the concommitant factor of undermatching. As experiment 1 followed one of the basic reasons for performing experiments; "... to explore the conditions under which a phenomenon occurs ..." (Sidman 1960, page 33), the adherence of switching to scheduled and obtained contingencies indicated the suitability of describing switching behaviour as a function of either scheduled or obtained reinforcements. The conditions can therefore be specified before subjects are placed in a free operant situation and their reactions to the programmed contingencies may be recorded for analysis. If, however, there is not a close correlation between obtained and scheduled reinforcements then the obtained values are more acceptable.

Experiment 1 supported the contention that the switching response originated by Findley has similarities to the Wyckoff observing response in which a specific behaviour distinctly separate from the immediate effects of primary reinforcement can be used to demonstrate preference (Autor 1969). Unlike the observing response however, the switching response does have an effect on the probability of reinforcement. Responding during the initial link of a concurrent-chains schedule also has similarities to switching behaviour because the relative response rate increases when it produces a preferred discriminative stimulus. However, unlike the concurrent-chains paradigm, the switching response is not a prerequisite to reinforcement, as the opportunity to gain reinforcement is concurrently available with the opportunity to switch. In the switching paradigm a discriminative stimulus signalling reinforcement availability is continuously present except where one component indicates extinction. Thus the organism is in a situation where opportunities for primary reinforcement are continuously available as in a free operant procedure and opportunities for demonstrating preference are concurrently available as well.

The extended switching procedure provides a method of permitting a choice between delayed or more immediate reinforcement. The preference for more immediate reinforcement, that is a shorter food schedule, predicted by earlier studies was confirmed in experiment 1 using the extended switching procedure. The second major factor remaining was the applicability of the procedure to demonstrate a preference for larger or smaller reward.

Results of experiment 1 support the general conclusion that although undermatching occurs on the food key, relative response frequencies approximate the relative reinforcement frequencies obtained. The prediction that relative responses on the switching key would more closely match the scheduled relative reinforcements was not confirmed. Responding

on the switching key did however match both scheduled and obtained reinforcements closer than did responding on the food key.

The issue of whether the switching schedule is a multiple or concurrent schedule is debatable. If it is conceded that the animal cannot respond concurrently to remove red and green then it appears that overmatching has occurred on a multiple schedule. That switching response rates are presented as a function of reinforcement frequencies is a debatable argument requiring clarification by further research.

If the view is taken that the subjects have the opportunity to switch at any time then the switching schedule is to be regarded as a concurrent schedule and response frequencies rather than rates are the appropriate measures.

The issue is complicated by the simultaneous availability of the food and switching key with opportunities to obtain food or to obtain a changeover being continuously available. To clarify the issue it would seem possible to arrange a more explicit multiple switching schedule with its own exteroceptive signals and investigate the possibility of matching to enter a terminal link. Such an investigation was beyond the scope of the present study as the primary aim was to investigate the prediction and control of switching as an option concurrently available with primary reinforcement availability.

Whether subjects match to reinforcement or maximise reinforcement is the subject of current debate (Herrnstein and Heyman, 1979). The issue is relevant to phase IV of experiment one where the mean interval between primary reinforcements was either 10 minutes of 66.67 seconds. If maximising reinforcements was the prime motivating influence, it might have been expected that subjects would have refrained from entering the 10 minute schedule. The commitment on entry to each food key schedule was on average 30 seconds and in phase IV the 40 reinforcements could have been gained in a shorter period by remaining in the VI66.67 component.

Although in phase IV, rates of responding which removed the shorter schedule fell to low levels (see appendix 1) the deviation from matching on the switching key was small (.05, .06, .10, .02). The matching hypothesis appears to have been supported. However, it is known that a switching schedule of FR1 without a COD results in a simple alternation between the food key stimuli thereby maximising opportunities for primary reinforcement (Skinner 1957b, page 211). While the VI30 second switching schedule in experiment 1 did not disrupt the matching relationship even at Conc. VI600-VI66.67 schedules, it was considered that a larger commitment to an unfavourable food key schedule should reduce the effect of matching as a controlling principle, in favour of maximising reinforcements. In experiment two, the effects of longer and shorter switching schedules were therefore investigated.

CHAPTER 3

EXPERIMENT 2: LONGER AND SHORTER SWITCHING SCHEDULES

Experiment 1 established the use of the extended switching procedure as an indication of the relative reinforcing strength of the food key concurrent schedules. The persistence of the switching response especially where the consequence was removal of a favourable schedule and entry into a much less favourable schedule raised the question - does the response support the matching hypothesis where responding is seen as conforming to a psychological principle, or the maximisation hypothesis where responding serves solely to maximise reinforcement? Herrnstein and Heyman (1979) found that subjects continued to adhere to the matching principle even though reinforcements were lost at the rate of 60 per hour.

The persistence of the switching response during preferred schedules of experiment 1 led to the present investigation of switching under more extended schedules. The 30 second commitment to an alternative food schedule was extended in experiment 2 by varying the schedule on the switching key from VI15 to VI180 under four different concurrent food schedules.

If behaviour was governed by maximisation principles the switching response was expected to decrease when longer schedules on the switching key were programmed in the presence of the preferred key colour and to rise when the less favourable food schedule was operating. At longer switching schedules rates of responding on the switching key in the preferred component should fall to minimal levels approaching extinciton. If matching between the two schedules was the governing principle the subjects would persist in switching even though that behaviour resulted in increasing the time to the next reinforcement.

METHOD

Subjects. Two pigeons, M6 and M7, previously used were maintained under the same conditions as in experiment 1.

Apparatus. This was the same as in experiment 1.

Procedure. Table 6 shows the experimental phases. Essentially, the food key schedules were held constant at two levels while the switching key schedule was systematically varied. Apart from an initial retraining period on concurrent variable interval schedules on the food key (Conc VI 120-VI 120) with the switching key schedule on VI60, both subjects began the experiment with exposure to a Conc VI 120-VI 120 food key schedule and a different schedule on the switching key. Both were exposed to four phases of Conc VI 600-VI 66.67 schedules. M6 was exposed to a further four phases of Conc VI 90-VI 180 while M7 was exposed to four phases of Conc VI75-VI300. Both subjects ended the experiment on baseline contingencies of conc VI120-VI120.

The schedule on the switching key was systematically varied. The switching schedule of M6 changed from VI180 through VI120, VI160 to VI15 and back through the same stages to VI180 during the other food key schedule. M7 changed from VI15 through VI60, VI120, to VI180 and back through the same stages to VI15.

Except for the systematic changes in schedules on both keys and the cessation of each session at thirty reinforcements, conditions were otherwise the same as in experiment 1.

Table 6. Response ratios on the switching key B_2/B_1 and the food key F_1/F_2 with obtained reinforcement ratios R_1/R_2. Steady state data are shown in the columns labelled sessions and slope. Data are from the last six sessions of each phase.

Pigeon	Phase	Food Key Schedule	Switching key Schedule	Sessions	Slope	Ratios		
						Reinforcement	Switching B_2/B_1	Food Key F_1/F_2
M6	I	conc. VI120 VI120	VI180	16	.001	.96	1.0	1.03
	II	conc. VI600 VI66.67	VI180	17	.004	.14	.37	.53
	III	conc. VI600 VI66.67	VI120	16	.005	.09	.09	.16
	IV	conc. VI600 VI66.67	VI60	16	.002	.15	.20	.50
	V	conc. VI600 VI66.67	VI15	16	.003	.08	.28	.14
	VI	conc. VI90 VI180	VI15	30	.002	1.95	1.35	.87
	VII	conc. VI90 VI180	VI60	14	.000	1.80	1.15	1.29
	VIII	conc. VI90 VI180	VI120	17	.001	1.40	2.71	.79
	IX	conc. VI90 VI180	VI180	15	.009	2.05	2.15	1.37
	X	conc. VI120 VI120	VI180	15	.004	.78	1.78	.98
M7	I	conc. VI120 VI120	VI15	14	.000	.98	1.48	1.00
	II	conc. VI600 VI66.67	VI15	13	.007	.11	.18	.09
	III	conc. VI600 VI66.67	VI60	18	.009	.15	.31	.22
	IV	conc. VI600 VI66.67	VI120	15	.002	.15	.38	.25
	V	conc. VI600 VI66.67	VI180	19	.002	.18	.65	.25
	VI	conc. VI75 VI300	VI180	14	.009	2.27	1.35	.93
	VII	conc. VI75 VI300	VI120	15	.005	4.0	.59	2.62
	VIII	conc. VI75 VI300	VI60	13	.008	2.83	1.66	1.49
	IX	conc. VI75 VI300	VI15	13	.009	3.39	1.90	1.94
	X	conc. VI120 VI120	VI15	14	.005	1.0	1.19	1.08

RESULTS

Ratios of $\frac{B_2}{B_1}$ are shown in Table 6 and the frequency of responses from which the switching ratios were derived are illustrated in figure 7. In figure 7 the baseline frequencies in phase I and II show that the subjects responded to remove the red and green colours when the food schedule was conc. VI120-VI120 even though in M6 the switching schedule was VI180. M6 in the final baseline showed a clear preference for green with a $\frac{B_2}{B_1}$ ratio of 1.78.

Phases II through V in figure 7 show the B_1 and B_2 frequencies when the concurrent schedules were Conc. VI600-VI66.67 and in each phase the shorter red schedule was preferred at each value of the switching schedule. All $\frac{B_2}{B_1}$ ratios were below 1.0.

When the food schedules were changed so that the green key colour indicated a shorter food schedule the switching response ratios reversed and exceeded the value of 1.0 except for M7 in phase VII. This discrepancy was caused by a low response frequency of 92 in red (session 3 at phase VII) and a contrasting high frequency of 772 in the green during the same session (see appendix 2).

The suggestion that long switching schedules would result in a near cessation of responding was supported by M6 in phase III. At VI120 the rates in the preferred red fell to less than one per minute. However, M6 rates were higher on a switching schedule of VI180 and in fact lower when the schedule was VI15. In session 15 of phase III a single response occurred on the VI120 switching key during the entire VI66.67 component. The B_2 rates of M7 were low in the favourable food schedule of VI66.67 but did not approach extinction as did M6 in phases III and V. Surprisingly the lowest rates for M7 occurred in session 13 of phase II when the switching schedule was VI15.

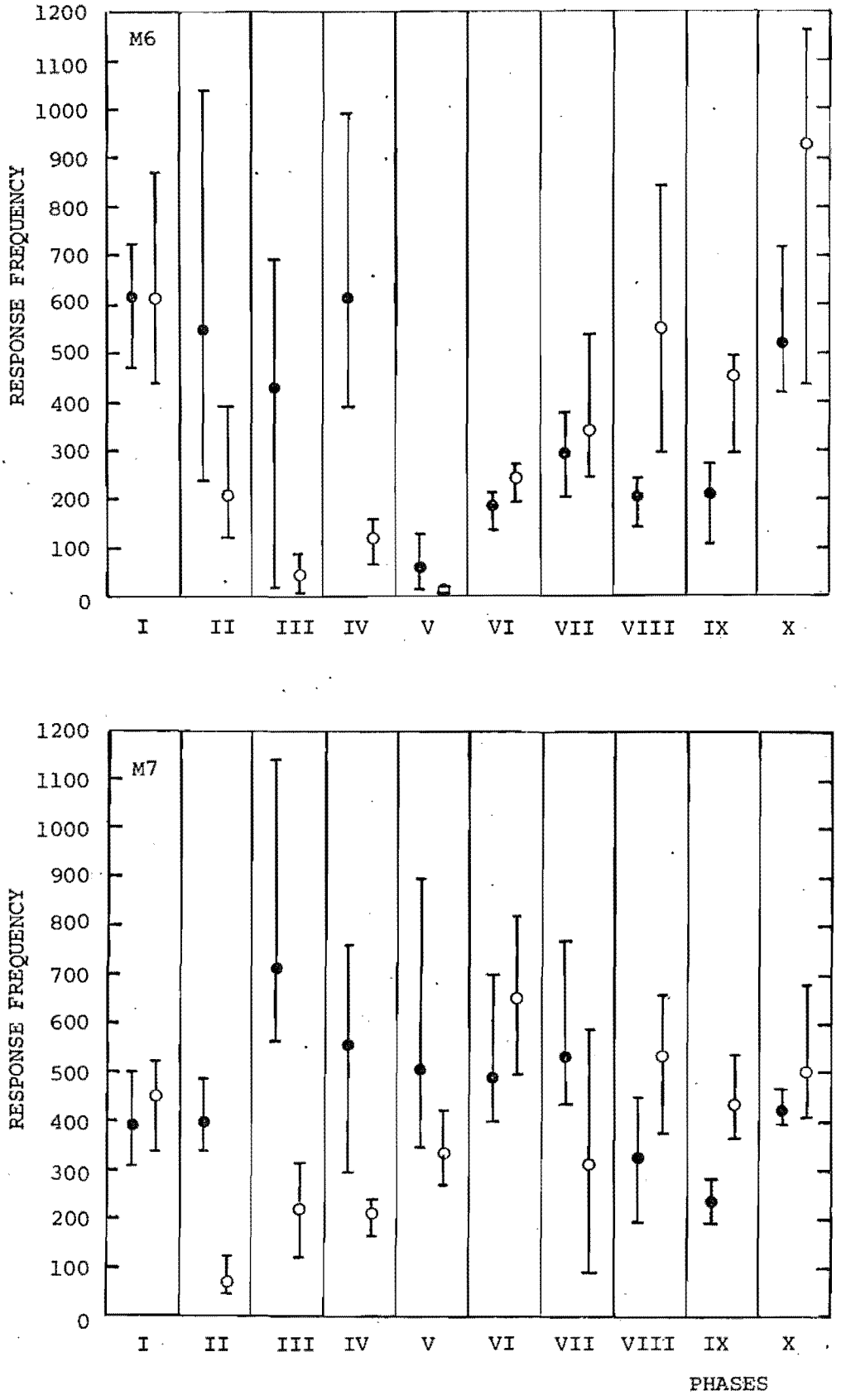


Fig. 7 Response frequency on the switching key when the food key was green (closed circles) and red (open circles). Data are the means and ranges from the last six sessions of each phase.

Consider the frequencies shown in figure 7 from phases II to V for both subjects. As the switching schedule decreased for M6 from VI180 to VI15 a fall in B_2 frequencies is evident. As the switching schedule for M7 increased in phases II through V there was a rise in B_2 frequencies. In both subjects the switching response in the less preferred schedule of VI600 remained high and largely unaffected by the switching schedule - except for M6 in phase V when it dropped sharply.

From the pattern of response frequencies of phases II through V it appeared that the behaviour in the VI66.67 schedule was influenced by the length of the switching schedule - increasing as the schedule increased, but the behaviour in the VI600 schedule was not influenced.

If so, then the M6 frequencies of B_1 in the shorter food schedules of phase VI through to IX should have increased as the switching schedule increased from VI15 to VI180. This did not occur but in fact the B_2 frequencies increased. In other words, switching responses in the presence of the longer food schedule (VI180) showed a rise as the switching schedule increased.

Predicting from the earlier patterns of phase II-V the values of B_1 in subject M7 could have been expected to decrease in phases IV-IX as the switching schedule decreased from VI180 to VI15. This tended to occur together with a slight fall in B_2 responding - exaggerated by the low frequency of B_2 in phase VII. It should be noted that the food schedules in phases VI-IX were conc. VI90-VI180 for M6 and conc. VI75-VI300 for M7.

M6 responded consistently during the presence of the red key colour - that is, as the switching schedule increased the response frequency increased but did not do so during the presence of green.

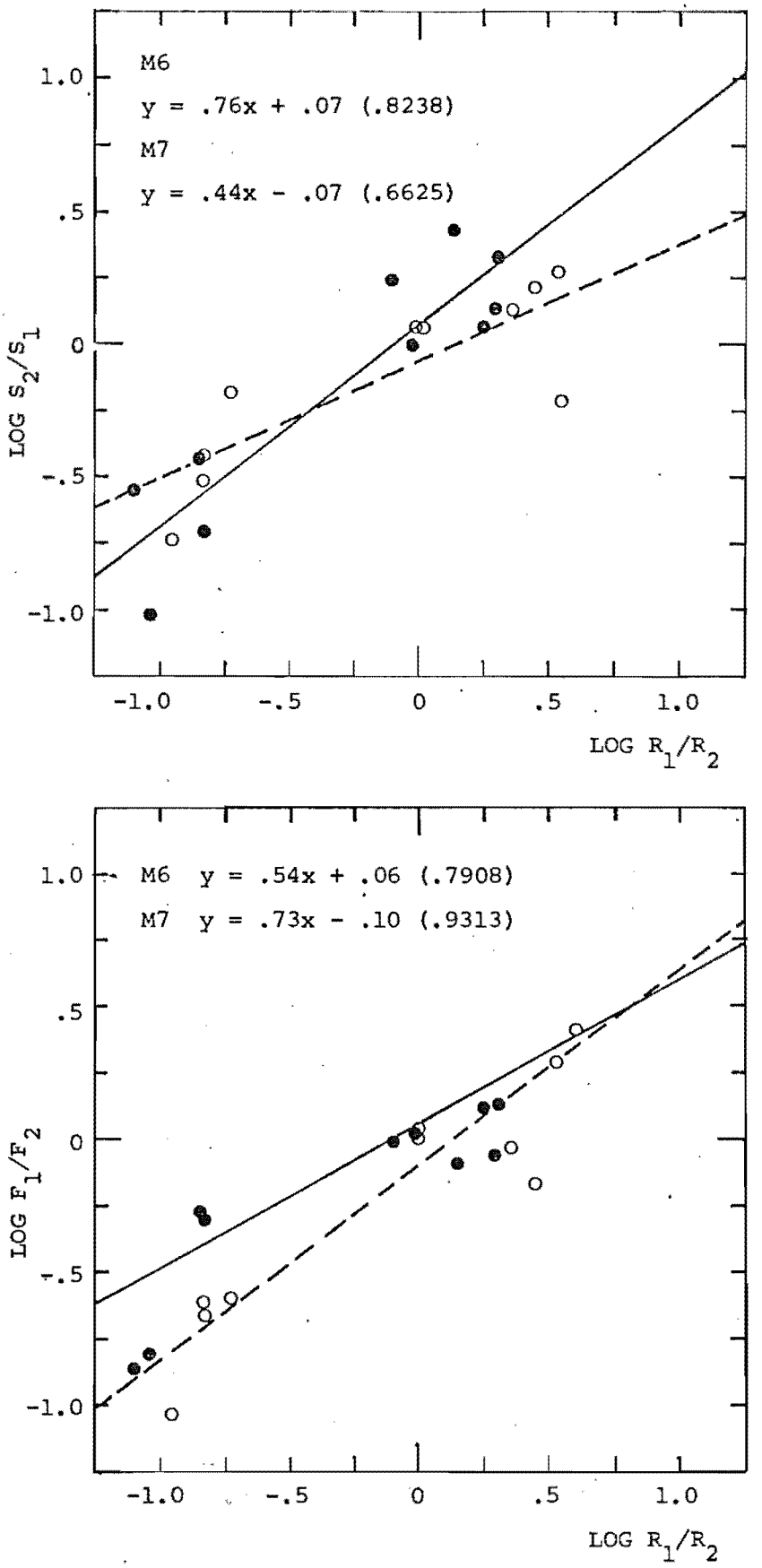


Fig. 8 Logarithms of response ratios as a function of log reinforcement ratios. Switching key functions (upper graph) and food key functions (lower graph) are shown for M6 (closed circles and solid line) and M7 (open circles and broken line). Variance accounted for is shown in brackets.

M7 responded consistently during the presence of the red key. That is, as the switching schedule increased, response frequency also increased. M7's B_1 frequencies fell according to predictions in the latter part of the experiment as the switching schedule decreased but remained stable in spite of switching schedule variations when the food key indicated VI600.

Visual inspection of figure 7 and reference to the switching column of table 6 shows switching ratios following the molar prediction that responding would persist in both schedules. With the exception of M7 in phase 7 the ratios were below 1.0 in phases II-V and above 1.0 in phases VI-IX.

In Figure 8 the upper graph shows responding plotted against reinforcement for all values of the switching schedule. The $\log\frac{B_2}{B_1}$ $\log\frac{R_1}{R_2}$ function was closer to matching for M6 with a sensitivity value of .76 and bias of .07. M7 was less with a sensitivity value of .44 and bias of -.07. Variance accounted for by the functions was .8236 for M6 and .6625 for M7. While both equations show a positive relationship between switching and obtained reinforcements, the fit is considerably less than obtained in experiment 1.

Figure 9 shows the mean frequencies of responding of the food key while the switching schedules were changed. Reference to figure 9 and the F_1/F_2 ratios in table 6 shows that the ratios stayed between .98 and 1.08 during the baselines. In phase II through V F_1/F_2 ratios remained below 1.0 with M6 varying more than M7. Responding in the shorter food schedule remained high and the responding in the VI600 schedule at lower levels. The ratio F_1/F_2 of M6 varied due to fluctuations in the response frequencies of both F_1 and F_2. In phases VI through IX F_1/F_2 ratios rose but only in two phases did M6 rise above 1.0 and the ratios generally were well below the obtained reinforcement ratios.

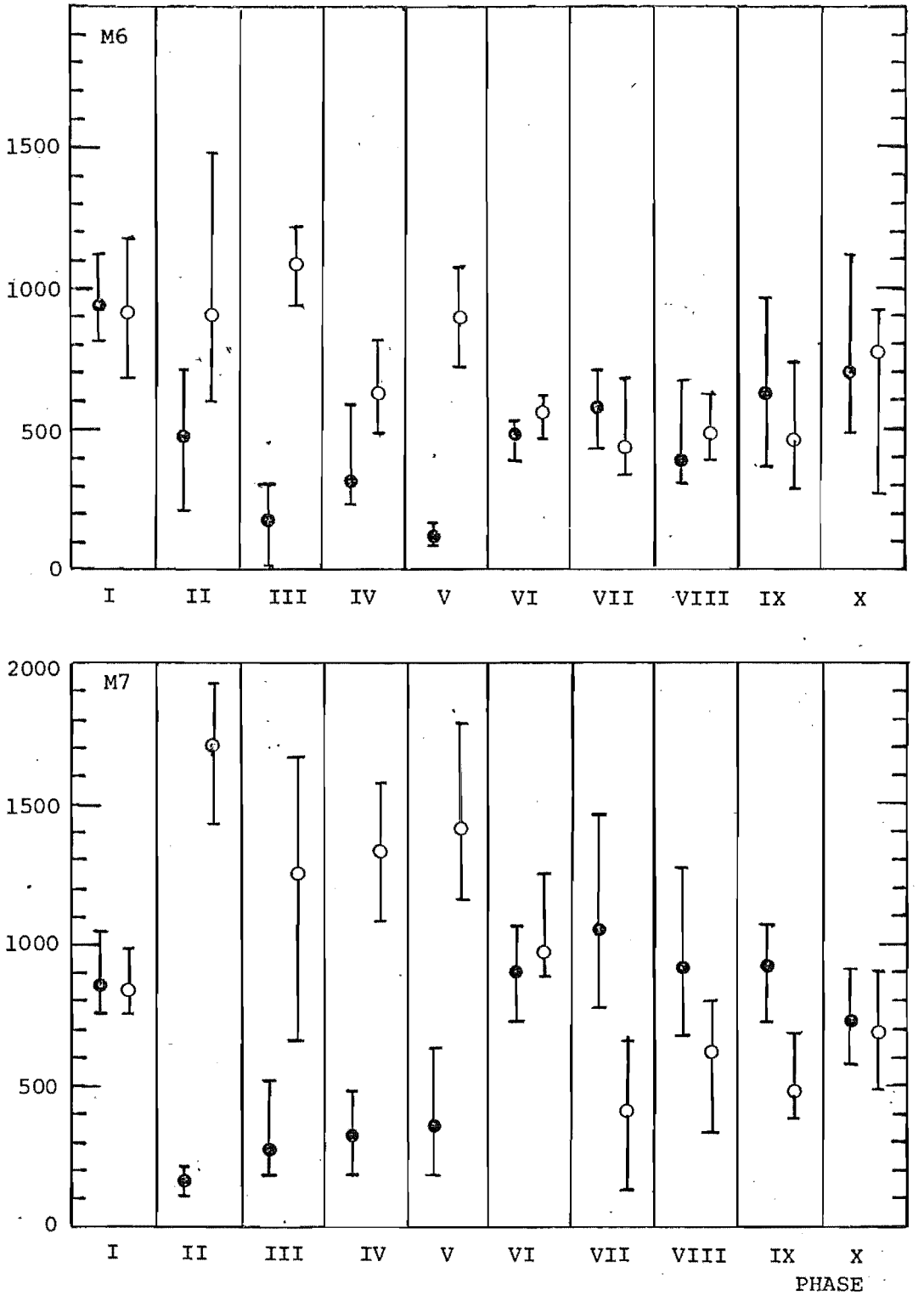


Fig. 9 Response frequency on the food key when the key was green (closed circles) and red (open circles). Data are the means and ranges from the last six sessions of each phase.

The functions plotted in figure 8 (lower graph) show that the food key responding of M7 fitted closer to the least squares line with .9313 at the variance accounted for by the equation y = .73x - .10. M6 responding produced .7908 of the variance accounted for by the equation y = .54 + .06. It is noticeable that the subject with the higher sensitivity in switching (M6) had the lowest sensitivity in food responding. Similarly M7 with a low sensitivity in switching had the higher sensitivity in food key responding.

The data from both subjects were combined, equations were calculated according to the length of the switching schedules and presented in table 7.

Table 7. Sensitivity (a) and bias (b) values of the combined data from M6 and M7. Log switching and food key ratios vs log obtained reinforcement ratios. Variance accounted for by each function is also shown.

switching schedule	B_2/B_1 a	b	VAC	F_1/F_2 a	b	VAC
VI15	.58	-.04	.947	.51	.40	.857
VI60	.63	-.08	.966	.52	-.04	.859
VI120	.54	-.16	.496	.69	-.08	.974
VI180	.48	.07	.874	.41	-.10	.712

At all values of the switching schedule undermatching occurred on both keys. From the combined data the only conclusion was that a weak but positive relationship continues to exist between switching and reinforcement regardless of the switching schedule lengths used in experiment two.

DISCUSSION

Results of experiment 2 were inconclusive and indicated the need for procedural modifications to investigate the effects of lengthening the switching response schedule as a major focus of study. The use of fixed or progressive ratios to measure response strength is one way of clarifying the contingencies which exert direct control over switching.

Perhaps the most significant result of experiment 2 was again the persistence of the switching response, especially when both the concurrent food key schedules and switching schedules were at their highest interreinforcement intervals.

In the Conc. VI600-VI66.67 condition when the scheduled $\frac{R_1}{R_2}$ was .111 every switch out of the VI66.67 schedule was counterintuitive. Thirty primary reinforcements were available to the subject in approximately 33 minutes on average by remaining in the presence of the red light. Although the theoretical minimum was 30 minutes according to the hyperbolic equation $\frac{1}{x} + \frac{1}{b} = \frac{1}{c}$ the delay to switching caused by the extended switching schedule resulted in times usually in excess of 33 minutes to obtain all reinforcements. At larger VI intervals on the switching key the total time to obtain 30 reinforcements was increased. When the switching schedule was VI180 and the food key schedules were Conc. VI600-VI66.67, M6 took a mean of approximately 46 minutes to obtain all reinforcements and M7 approximately 39 minutes. In the preferred key colour M6 performed a mean of 202 switching responses at a rate of 7.30 per minute while M7 performed 329 at a rate of 14.79 per minute. In phase III however, M6 performed at a lower rate when the switching schedule was VI120 completing a mean of 40.33 switching responses at a rate of 1.78 per minute. The persistence of the switching response diminished in session 15 of phase III to only one response during red and 24 in green. As a consequence the total time to obtain 30 reinforcements

was 26 minutes, but in the following session, 83 responses occurred in red and the time to complete the session subsequently increased to 37 minutes.

Consider a situation where the animal has just changed into the red on a VI180 switching schedule with the food schedule at Conc. VI600-VI66.67. The choice at the point of transfer to red is between reinforcement during red in 66.67 seconds on average or responding on the switching key to obtain reinforcement in 600 seconds, on average. That is, in the mean 180 seconds needed to effect a changeover to green and whatever time remains to reinforcement in green. A clear preference for red would be predicted and this was apparent in figure 7.

Consider the situation where the animal has just changed into the red on a VI180 switching schedule with the food key at Conc. VI90-VI180. The choice confronting the animal is then between responding on the red food key to receive reinforcement in 180 seconds on average or responding on the switching key to change colour and receive reinforcement again in 180 seconds. That is, the time to complete the VI180 switching schedule by which time a food reinforcement is likely to be set up in green.

The requirements of the switching schedule, especially if they exceed those on one of the food schedules, should logically exert some influence on choice and is a complex issue raised but not solved by experiment two.

In general although no firm relation was established between switching schedule length and accuracy of matching, the switching response failed to extinguish completely. The two issues arising from experiment 1 relevant to the present study were the effects of the switching key schedule and those of the food key schedules. Although the switching schedule effects require further investigation using different types of schedules it was established in experiment 1 that for the purposes of the present study, a VI30 schedule provides an adequate indication of preference. In the remainder of this study therefore, VI30 schedules were

used exclusively on the switching key while the consequences of entering and withdrawing from the food key alternatives were manipulated.

With equal concurrent schedules switching behaviour results in switching ratios of approximately 1.0. When differential contingencies exist on the concurrent schedules, any change in ratios is attributed to these differences.

The extended switching procedure has been presented as a measure of preference when inherent advantages of switching are present. A significant side issue to the present field of inquiry is the utility of the procedure when the inherent advantages of switching are not present. That is, when reinforcement frequency differential is the only consequence of changeovers, does the switching response persist? Experiment three investigated this issue.

CHAPTER 4

EXPERIMENT 3: SWITCHING AND MULTIPLE SCHEDULES

INTRODUCTION

In concurrent schedules such as those used in experiment 1 and 2 the emission of a successful switching response ends the schedule component then in force and switches the other component into effect. So both the duration of the component and which component is in effect are controlled by the subject through the switching response.

In contrast, in a multiple schedule two or more schedules determine reinforcements with each component signalled by a correlated exteroceptive stimulus but the duration of each component is fixed as is the order in which they appear. The order may be irregular or alternating. No switching behaviour is involved and the subject cannot influence the duration of the component nor determine which component is in force at any time. A modification called the advance key procedure (Honig, Beale, Seraganian, Lander and Muir 1972) adds a switching response to the multiple schedule. By making a switching response the subject terminates the component thus determining its duration and produces the next scheduled component. In the absence of switching behaviour the components change at regular intervals.

A further modification of the advance key procedure employed in this study adds the further feature that the switching key response always brings the alternate component into effect, i.e. the maximum duration of each component is set by the experimenter but the minimum duration is controlled (within switching schedule inter-reinforcement limits) by the subject.

In concurrent schedules there is an inherent advantage in switching between components because the two schedules continue independently. The probability of a reinforcement becoming available on one schedule increases automatically while the other schedule is in effect. Switching therefore reduces the overall delay to reinforcement in concurrent schedules (Squires and Fantino 1971). However, the persistence of the switching response especially in experiment 2, actually increased the delay to receive reinforcements. If probability of reinforcement is related to scheduled rate of reinforcement then it may be assumed that even a low probability as in the VI600 second component was sufficient to maintain a low but persistent switching response.

Experiment 3 sought to remove the probability of a reinforcement becoming available in the other component but maintaining a differential rate of reinforcement between the red and green components by changing the food schedules from concurrent to multiple. It was predicted that without the inherent advantages of switching the subject's switching behaviour would extinguish during the signal correlated with the higher rate of reinforcement As termination of the signal correlated with the higher rate of reinforcement was unlikely, the usual measure, B_2/B_1 on the switching key was inappropriate with a zero rate predicted during the more valued food key stimulus regardless of the strength of response in the less preferred signal.

The issue was thus reduced to the question - 'without the inherent advantages of switching common in concurrent schedules, does switching behaviour provide an adequate measure of preference?'

In accordance with Sidman's philosophy, experiment 3 sought not to eliminate switching but to investigate its controlling factors. The experiment was thus designed to investigate the extended switching procedure as a means of predicting preference for alternating components of a multiple schedule. By alternating components rather than programming them irregularly and by permitting the subjects to switch, both the maximum duration and choice of component in effect were under the subject's control.

When pigeons are exposed to concurrent VI-VI schedules and a VI30 switching schedule the relation between switching and reinforcement conforms to the matching law. When exposed to multiple schedules without a switching key pigeon's responses do not usually conform to the matching law (Reynolds 1961, Lander and Irwin 1968). The relationship has been termed undermatching by Baum (1974), Shimp and Wheatley (1971), Killeen (1972) and Todorov (1972). Merigan, Miller and Gollub (1975) obtained approximate matching in multiple schedules only when the components alternated rapidly and considered that spatial separation of components was also a necessary factor.

The possibility of matching in experiment 3 was a secondary issue restricted to behaviour on the food key while the primary issue was the response rate on the switching key as a function of food key contingencies. The contingencies were scheduled by holding a VI60 schedule constant in one component and varying scheduled reinforcement rates in the other. To ensure a relative measure of switching it may have been possible to incorporate a form of concurrent chains procedure,with switching in the initial link,necessary to enter a terminal link of multiple schedule components,but this was rejected. The purpose of the overall study was to investigate

switching as a choice behaviour concurrently available with food producing behaviour, not as a prerequisite to obtaining primary reinforcement.

METHOD

Subjects. Two pigeons M5 and M8 previously used were maintained under the same conditions as in experiment 1.

Apparatus. This was the same as in experiment 1.

Procedure. Table 8 shows the experimental phases. Both subjects began and ended the experiment with exposures to Conc. VI120-VI120 schedules on the food key. Phases II through to IX were multiple schedules beginning with Mult VI60-VI60, through Mult ext-VI60, Mult VI180-VI60, to Mult VI120-VI60, then reversed from Mult VI60-VI120 through Mult VI60-VI180, Mult VI60-ext, Mult VI60-VI60.

The schedule on the switching key remained at VI30 throughout. Components of the multiple schedule which were not terminated by a successful switching response automatically changed to the alternate key colour after 90 seconds, with a five second blackout between components. The blackout which served to minimise interactions between components occurred only when the experimenter advanced the schedule.

As switching behaviour was the independent variable of interest, phases terminated when switching response had stabilised. Relative rates were used in the concurrent phases I and X as in experiment 1, but were inappropriate in the multiple schedule phases because of the expected low rates in the presence of the preferred key colour. Therefore the steady state criteria of Cummings and Schoenfield (1960) for rates were adopted. The first seven sessions were allowed for adjustment to the experimental conditions. Thereafter the mean response rates on the switching key for the next six

Table 8. Mean response rates on the switching key, food key and ratios of food key response. Also shown are the ratios of obtained reinforcement. Steady state data are shown in the columns labelled slope and sessions. Data are from the last six sessions of each phase.

Pigeon	Phase	Food key schedule	Slope	Sessions	Resp. rate sw. key during		Resp. rate food key during		Ratios	
					green	red	green	red	F_1/F_2	R_1/R_2
M5	I	conc. VI120 VI120	.003	14	24.03	25.34	34.29	35.70	.66	.83
	II	mult. VI60 VI60	<3p.m.	14	2.17	3.51	64.92	77.83	.83	.83
	III	mult. Ext. VI60	.05	17	42.70	.05	5.61	84.86	.07	0
	IV	mult. VI180 VI60	.01	14	19.17	.03	23.41	83.06	.28	.39
	V	mult. VI120 VI60	.00	15	1.35	.00	49.98	105.17	.48	.42
	VI	mult. VI60 VI120	<3p.m.	16	.20	.50	65.97	77.96	.84	2.53
	VII	mult. VI60 VI180	.01	17	.02	12.11	81.65	33.16	2.46	6.75
	VIII	mult. VI60 Ext.	.00	14	.03	28.21	86.96	11.47	7.58	-
	IX	mult. VI60 VI60	.02	18	.19	5.60	85.13	46.52	1.83	.87
	X	conc. VI120 VI120	.007	13	23.89	20.79	46.85	49.80	.94	1.05
M8	I	conc. VI120 VI120	.000	15	19.18	16.38	35.61	44.32	.86	1.05
	II	mult. VI60 VI60	<3p.m.	21	.15	1.17	50.40	51.47	.98	1.04
	III	mult. Ext. VI60	.01	20	10.76	.02	6.82	96.24	.07	0
	IV	mult. VI180 VI60	.02	14	6.83	.00	35.76	79.13	.45	.41
	V	mult. VI120 VI60	.02	16	2.60	.01	39.12	76.71	.51	.39
	VI	mult. VI60 VI120	.01	19	.20	3.83	73.91	37.14	1.99	2.28
	VII	mult. VI60 VI180	.02	18	.09	5.56	74.99	48.05	1.56	3.41
	VIII	mult. VI60 Ext.	.02	15	.01	9.91	71.43	6.98	10.23	-
	IX	mult. VI60 VI60	<3p.m.	13	.13	.48	66.08	66.43	.99	.89
	X	conc. VI120 VI120	.002	13	9.52	8.25	43.81	53.42	1.05	.98

days were used to assess stability. If the difference between the means of the first three and the last three of the final six sessions was no more than 5 percent (.05) of the overall mean, the response rates were considered to be in a steady state. However, if rates of responding fell below three per minute in both components, for three consecutive sessions that phase of the experiment was terminated and the next phase begun. The phases in which rates fell below three per minute are indicated in the slope column of table 8 by the symbol <3 p.m. Other conditions were the same as in experiment 1, but with each session ending when 30 reinforcements had been obtained.

RESULTS

Rates of responding calculated as response frequency divided by time in stimulus on switching and food keys are shown in Table 8. The rate of response on the switching key dropped sharply following the change from equal concurrent to equal multiple schedules (phase I and II) and rose sharply in the reverse situation (phase IX and X).

In Figure 10 it is seen that switching rates dropped to minimal levels in the multiple VI60-VI60 schedules (phase II and IX) except for M5 which continued to respond in the red key colour at 5.6 responses per minute in phase IX. Reference to Figure 11 shows that food key responses by M5 were discrepant also during phase IX where the VI60 green component rates were 85.13 per minute and the red VI60 components were 46.52 producing a ratio of 1.83.

The major effect of removing the inherent advantage of switching was that switching behaviour decreased substantially and increased when the concurrent schedule was reinstated. M5 and M8 responded on the switching key at less than 3 per minute in phase II and in phase IX, M8 responded at similarly low rates.

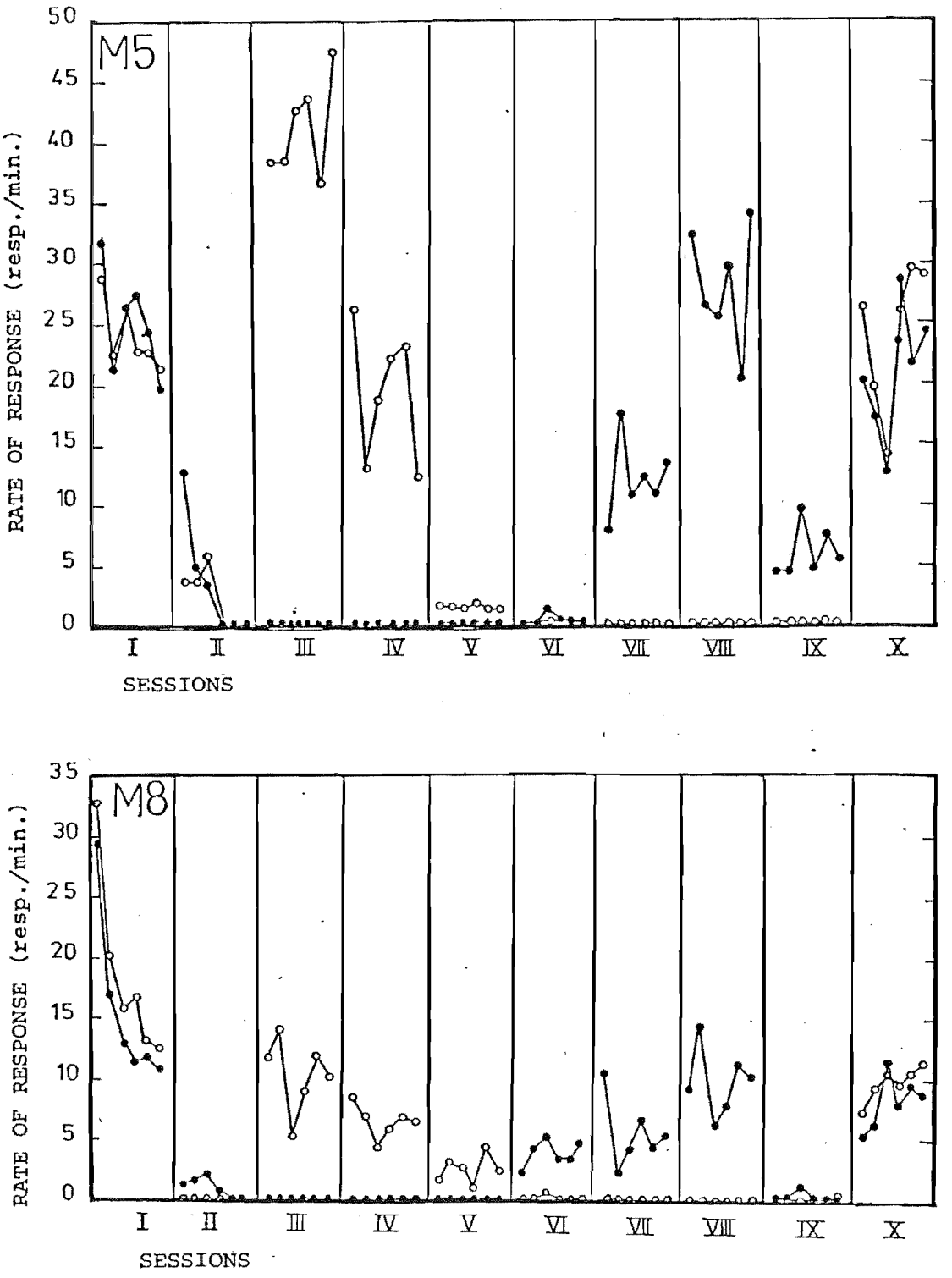


Fig. 10 Rate of response on the switching key during changes in the scheduled reinforcement rate on the food key. Rates during the green coloured food key (open circles) and the red colour food key (closed circles) are from the last six sessions of each phase. Schedules with green colour indicated first were Conc VI120-VI120 (Phase I) Mult VI60-VI60 (Phase II) Mult Ext-VI60 (Phase III), Mult VI180-VI60 (Phase IV), Mult VI120-VI60 (Phase V), Mult VI60-VI120 (Phase VI) Mult VI60-VI180 (Phase VII), Mult VI60-Ext (Phase VIII) Mult VI60-VI60 (Phase IX) and Conc VI120-VI120 (Phase X).

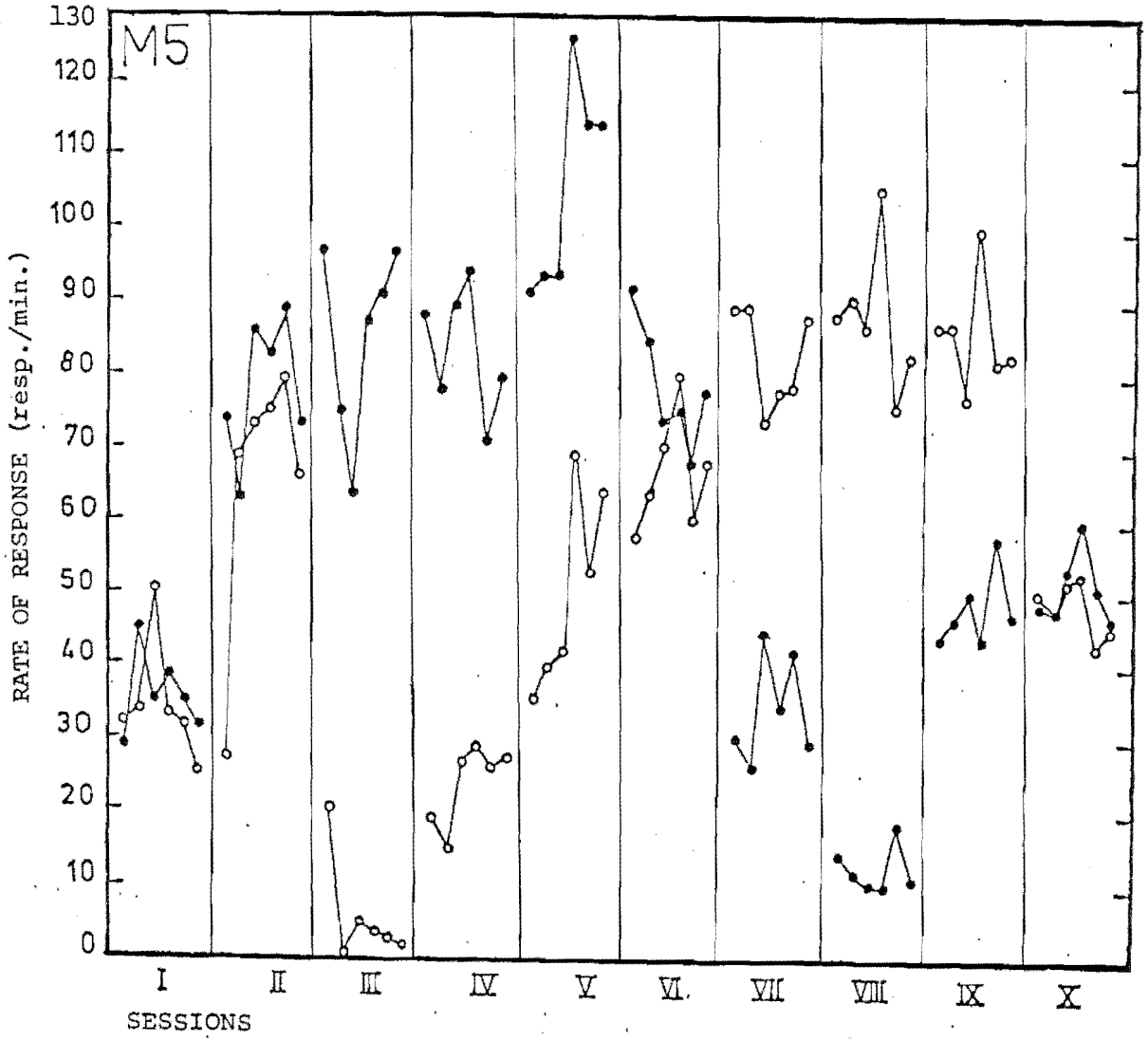


Fig.11 Rate of response on the food key during green (open circles) and red (closed circles). The schedules with green key colour indicated first, were Conc VI120-VI120 (Phase I), Mult VI60-VI60 (Phase II), Mult Ext-VI60 (Phase III), Mult VI180-VI160 (Phase IV), Mult VI120-VI160 (Phase V), Mult VI60-VI120 (Phase VI), Mult VI60-VI180 (Phase VII), Mult VI60-Ext (Phase VIII), Mult VI60-VI60 (Phase IX), and Conc VI120-VI120 (Phase X). Data shown are from the last six sessions of each phase.

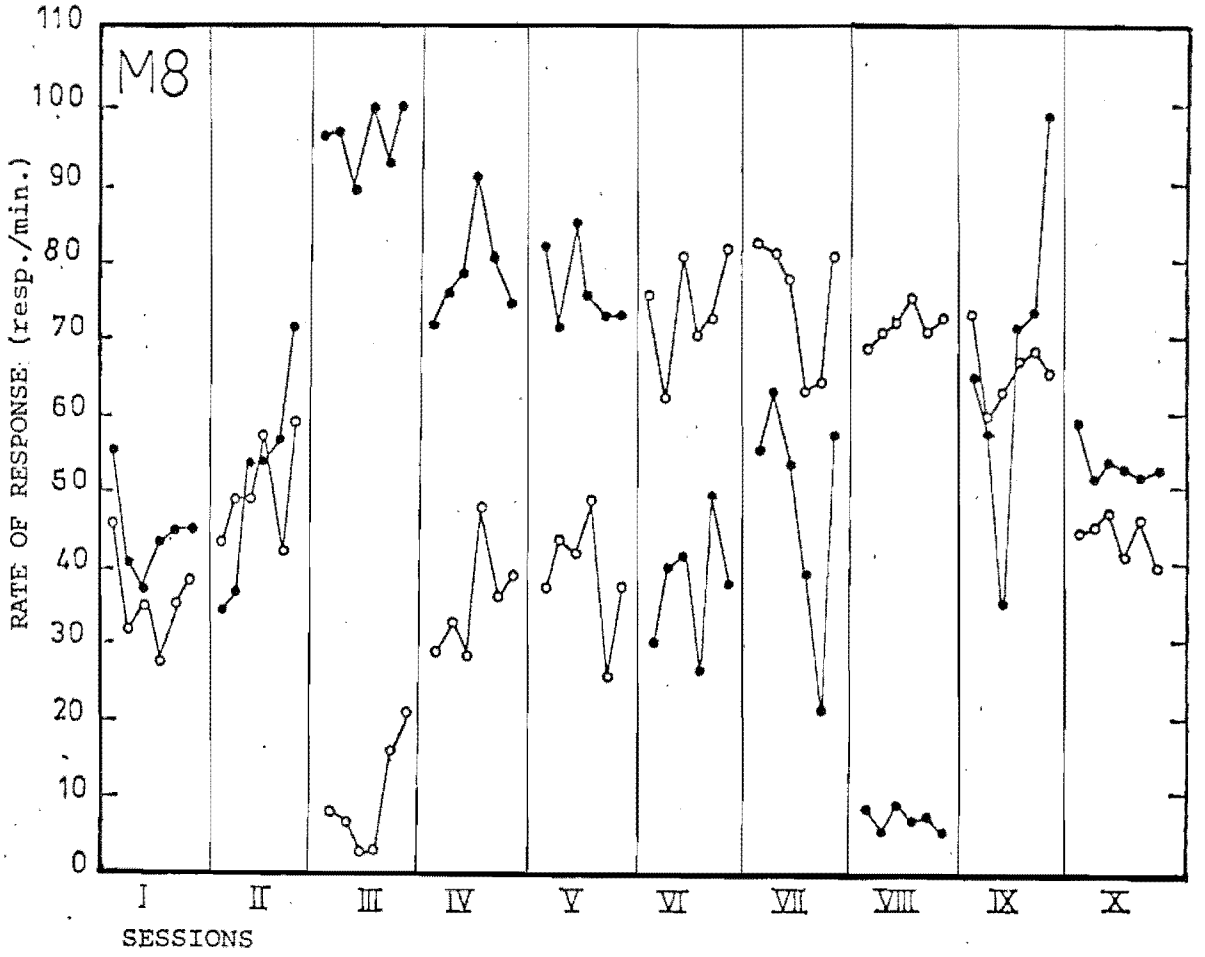


Fig. 12 Rate of response on the food key during green (open circles) and red (closed circles). The schedules, with green key colour indicated first were Conc VI120-VI120 (Phase I), Mult VI60-VI60 (Phase II), Mult Ext-VI60 (Phase III), Mult VI180-VI60 (Phase IV), Mult VI120-VI60(Phase V), Mult VI60-VI120 (Phase VI), Mult VI60-VI180 (Phase VII) Mult VI60-Ext. (Phase VIII), Mult VI60-VI60 (Phase IX) and Conc VI120-VI120 (Phase X). Data shown are from the last six sessions of each phase.

In this study S^+ refers to a stimulus in which reinforcement is available and S^- refers to a stimulus where reinforcement cannot be gained, i.e. extinction. Where the distinction between two stimuli is that of different rates or amounts of reinforcement, the symbols S^1 and S^2 have been adopted. S^1 refers to the stimulus correlated with the higher rate of reinforcement and S^2 refers to the stimulus correlated with the lower rate.

Multiple schedules in which one of the components was extinction (S^-), produced a rapid increase in switching out of the extinction colour (phases III and VIII) illustrated in Figure 10 for switching responses and Figures 11 and 12 for food key responses. During phases III and VIII switching responses in the VI60 component dropped to a combined mean of .028 per minute while food key responses in the extinction component dropped to a combined mean of 7.72. The greater effect evident on switching behaviour suggests that switching provides more information on the value of S^+ and S^- than does the behaviour on the food key.

However, the critical test involved phases IV through to VII where the dichotomy of S^+ versus S^- was changed to one of more reinforcement versus less. That is, where both colours on the food key were different discriminative stimuli, S^1 or S^2, signalling the availability of reinforcement.

Where the schedules were equivalent, switching behaviour virtually ceased and the F_1/F_2 ratio approached indifference. For M8 the ratios were .98 and .99 while for M5 the ratios were .83 and a discrepant 1.83

Switching behaviour illustrated in figure 10 was minimal in the presence of colours indicating the more generous reinforcement schedule. Thus in all phases the VI60 schedule was preferred although

the rates of M5 during phase VI were very low (.20 and .50 responses per minute). During phase IV with the green colour signalling VI180, M5 responded on the switching key at a rate of 19.17 per minute compared to 0.03 in the VI60 component resulting in a total of 115 changeovers out of green compared to a total of 3 changeovers out of red (see appendix 3, sessions 9 through 14).

Again in phase VII where the schedules were reversed, M5's switching rate out of the VI180 schedule was 12.11 per minute compared to .02 per minute in the VI60 component resulting in 145 changeovers out of red in the last six sessions and only two out of the green colour. The comparable figures for M8 during phase IV were rates of 6.83 per minute and 0.00 resulting in 99 changeovers from VI180 and none from VI60. In phase VII switching rates for M8 were 5.56 per minute during VI180 and 0.09 during VI60, resulting in 118 changeovers from green and 9 from red.

In phases V and VI the food key schedules were Mult VI120-VI60 and Mult VI60-VI120. Both subjects responded more on the switching key during the VI120 component but at slower rates than in the corresponding VI180 components of phase IV and VII. In phase V, M5 responded at 1.35 per minute during VI120 and zero during VI60, and in phase VI responded slowly at .50 per minute during VI120 and .20 during VI60. M8 responded at 2.60 per minute in VI120 and 0.01 in VI60, while in phase VI corresponding rates were 3.83 and 0.20 per minute. In phase V, M5 produced 59 changeovers out of the VI120 component and none from VI60, while in phase VI produced 53 changeovers from VI120 and 10 from VI60. The corresponding changeovers for M8 were 79 from VI120 and 1 from VI60 and in phase VI, 74 from VI120 and 2 from VI60. The minimal switching rates during VI60 components and subsequent high rate of switching out of the less preferred component rendered the use of B_2/B_1 inappropriate as a statistic. At best the

rates of switching provide an ordinal indication of preference. It is unlikely that the measure is sensitive enough to provide finer discrimination between multiple food key schedules with shorter inter-reinforcement intervals.

In figure 13 the logarithmic functions between food key sensitivity and obtained reinforcement is seen. With M5 sensitivity at .56 and M7 at .64 the results are in line with other research which demonstrates undermatching in multiple schedules (Baum 1974, Todorov 1972).

In Figures 11 and 12 food key rates during green and red are shown. In phases III through V the red component schedule remained at VI60. Rates during the VI60 component were relatively stable while the rates during the systematically altered component varied with the alterations. In phases VI through to X when the green colour signalled VI60 a similar stability in response rate was observed. Thus the relative rates, varied mainly because of changes in the systematically varied component. In phases III through to VIII the mean response rate of M5 on the food key during all VI60 components was 84.61 (S.D. = 12.55) and for M8 the mean rate was 78.74 (S.D. = 8.96). In the component which was varied the mean response rate for M5 was 33.60 (S.D. = 26.88) and for M8 the mean was 28.98 (S.D. = 17.63).

Positive contrast is sometimes obtained in multiple schedules when rates in one component rise above a baseline level although the schedule in that component has remained the same. This effect is seen in Figures 11 and 12, when the food key rates in the VI60 component rose. The effect is seen in phase III when the rates of M5 rose slightly and M8 sharply.

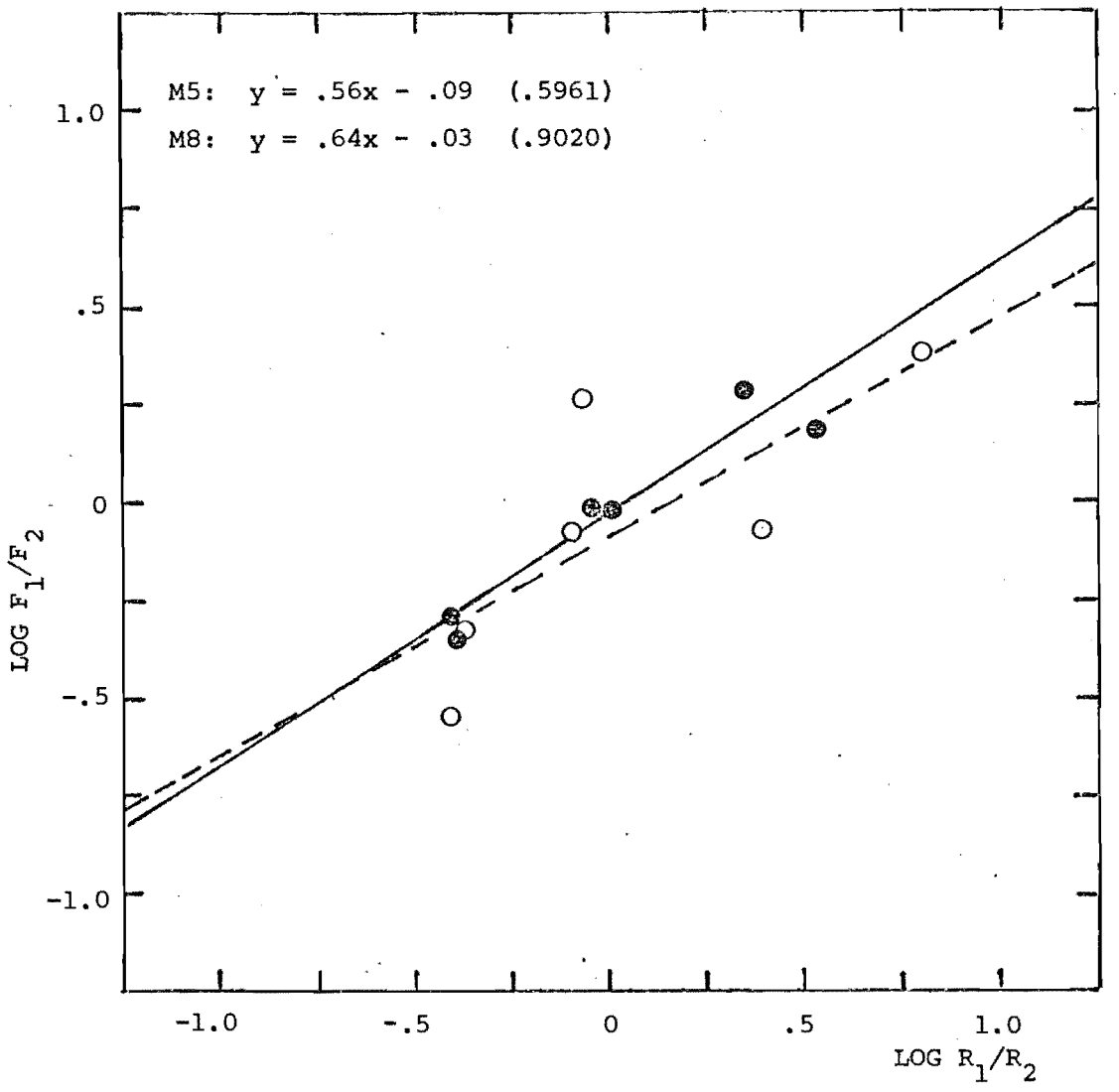


Fig. 13 Logarithms of response ratios plotted as a function of log reinforcement ratios during the multiple schedules of phases II, IV, V, VI, VII and IX. Functions for M5 are shown by open circles and the broken line. Functions for M8 are shown by closed circles and solid line. Variance accounted for is shown in brackets.

Some contrast is evident in the food key rate of M5 (Figure 11) in phases VI through to IX where the rate during green rose from 65 per minute to over 80 per minute. This was not seen in M8 (Figure 12) where the rates remained at approximately 70 per minute.

DISCUSSION

As an indicator of preference for multiple food schedules, switching rate is at best an ordinal measure. Further investigation is necessary with the switching paradigm arranged so that a relative rate can be obtained on the switching key. This could be arranged by making switching a prerequisite for reinforcement or by providing two switching keys, one for entry into red and the other for entry into green. These possibilities were considered in the present study but were rejected as digressions from the central themes - that of a switching response on a single operandum as an explicit measure of preference concurrently available with food reinforcement.

In experiment three the relative rates on the food key provided a better indication of preference although undermatching occurred. In some phases where contrast effects were seen the subjects showed less discrimination between the multiple schedule components than in previous experiments where the food schedules were concurrent. The use of ratio food schedules where a specific number of responses is necessary to obtain reinforcement may have produced clearer discrimination in both the food key and switching behaviour.

The relation between switching behaviour and reinforcement is however, sufficiently well established when concurrently available differential reinforcement is available on VI schedules. Experiment 1 established the basic axium that the switching response when scheduled provided an indication of preference. Experiment 2 in which the

switching schedules were varied established that although the molecular aspects of the switching schedule affected switching behaviour the response was sufficiently strong to persist in counterintuitive situations and therefore molar contingencies exert significant control.

As the central theme of the present study was self control, i.e. the issue of less reward sooner versus more reward later, it was necessary to determine the appropriateness of the extended switching procedure to the last remaining molar variable under consideration - that of greater or smaller reinforcement.

In the following experiment the scheduled reinforcement rate was held constant with conc VI75-VI300 schedules on the food key, the switching schedule was held constant at VI30 and the duration of reinforcement was systematically varied.

CHAPTER 5

EXPERIMENT 4: THE EFFECT OF REINFORCEMENT MAGNITUDE ON EXTENDED SWITCHING BEHAVIOUR

INTRODUCTION

Reinforcement magnitude is somewhat of a misnomer in the experimental analysis of behaviour since, by definition, a reinforcer is a consequence (i.e. an event measured by its frequency) which increases the likelihood of a response reoccurring rather than a quantity. Some studies have found that increasing the amount of food for deprived organisms has little effect on response rates (Catania, 1963; Keesey and Kling, 1961; Schrier, 1962; Shettleworth and Nevin, 1965; Shwartz, 1969; Powell, 1969). Earlier studies (Crespi, 1942; Zeaman, 1949 and Guttman, 1953) suggested that greater reinforcement was correlated with greater incentive but others suggested that it had an inverse affect (Lowe, Davey and Harzem, 1974; Staddon, 1970). Concurrent chains schedules in which the basic dependent variable is taken from the initial link of the chain provide more consistent results. Neuringer (1967) found that pigeons' response rates were unaffected by differences in the duration of access to grain reinforcement, but when permitted to choose, preferences were linearly related to reinforcement duration. While multi operandum or choice experiments yield a functional relationship between allocation of choice responses and the obtained amount of food, single operandum experiments have been generally unsuccessful.

Although response rates are insensitive to reinforcement magnitude, Powell (1969) and Staddon (1970) found that the post-reinforcement pause (PRP) lengthened as reinforcement duration increased. Some studies have subsequently recorded rates without

including the PRP time in the temporal denominator and found some relation between later responding and magnitude, although average rates remained insensitive (Osborne, 1978).

Two important aspects which have affected research investigating reinforcement magnitude effects are firstly the discriminative stimuli controlling the response and second the real contingencies of reinforcement. Mariner and Thomas (1969) analysed different reinforcement durations as variations in the delay of the end of the food magazine cycle. If two reinforcements exist with the smaller at two seconds duration it is only after the two seconds have elapsed that a pigeon could be differentially affected by different feeder cycles.

> "This delay of differential consequences of responding would be expected to reduce the effect of the difference between reinforcement durations."
>
> (Mariner and Thomas, 1969, page 760.)

They overcame the problem by correlating different dispenser light intensities with different reinforcement durations and obtained a significant effect of magnitudes of reinforcement.

When the complex chains of stimuli and responses involved in consummatory behaviour of a pigeon feeding from a magazine are considered, it is not surprising that the continuation of a magazine light for a few extra seconds exercises little discriminatory control over the pigeon's preceding behaviour. Pigeons' inability to discriminate between components of second order schedules unless a unique exteroceptive cue is provided for each component (Squires, Norburg and Fantino, 1975) supports the view that the discriminability of environmental cues is a vital factor.

The second factor concerns the actual contingencies of reinforcement operating. Neuringer (1967), commenting on the insensitivity of response rates to reinforcement duration changes suggested that the effects of magnitude of reinforcement depend upon magnitude being contingent on responding. As a measure of the effect of discriminative stimuli signalling differential reinforcement magnitude, Augue (1973) used the observing response as a dependent variable (Wyckoff 1969). Observing responses produced a 10 second or continuous signal that indicated reinforcement magnitude which was either 2 seconds or 10 seconds. Observing responses were maintained for the longer continuous stimuli but decreased when only a 10 second signal appeared and those that signalled the larger magnitude were also more effective.

From the above research emerge three conditions which are necessary to develop a paradigm by which responding on a single operandum could provide a reliable indication of preference for reinforcers of different magnitude.

The behaviour should not be affected unduly by post-reinforcement pauses, responding should produce a continuous signal indicating differential magnitude and reinforcement duration should be contingent on response rate. The present study with the dependent variable taken from responding on one white key was an attempt to fulfil these conditions.

Post reinforcement pauses are uncommon in VI schedules and occur mainly on the food key. The VI30 switching schedule used in experiments 1 and 3 was free of post reinforcement pauses. Like the observing response, switching behaviour provides continuous information about the schedule in effect, yet at the same time has a direct influence on availability of the schedules. The amount of reinforcement received is thus contingent on the organism's responding at the

switching key.

Experiment four was, then, a test of the basic extended switching procedure's effectiveness in demonstrating preference for longer reinforcement duration.

METHOD

Subjects. Three experimentally naive homing pigeons M9, M10 and M11, were maintained at 80% plus or minus 15 grams of their free feeding body weight under the same conditions as in experiment 1.

Apparatus. This was the same as in experiment 1.

Procedure. Initial training was the same as in experiment 1 until the pigeons responded consistently on a Conc VI120-VI120 food key schedule with the switching key schedule on VI30 and the food dispenser duration set at 5 seconds in each component.

Table 9 shows the exposures to the experimental conditions, the number of sessions and the steady state data. The programmed relative rate of reinforcement remained equal in each key colour throughout all phases. In phase I (baseline), dispenser durations were equal at 5 seconds in each component. In phase II the dispenser durations were 2 seconds in green and 8 seconds in red. Durations were reversed in phase III and in phase IV returned to those of the baseline.

Except for the dispenser durations and the cessation of sessions after 30 reinforcements, conditions were the same as in experiment 1.

Table 9. Ratios of switching, food key responding and access to reinforcement $\frac{RD_1}{RD_2}$. Steady state data are shown in the columns labelled slope and sessions. Data are from the last six sessions of each phase.

Pigeon	Phase	Schedule	Reinf. duration (secs) G	R	Slope	Sessions	Ratios $\frac{B_2}{B_1}$	$\frac{F_1}{F_2}$	$\frac{R_1D_1}{R_2D_2}$
M9	I	conc. VI120 VI120	5	5	.005	20	1.70	.68	.91
	II	conc. VI120 VI120	2	8	.003	23	.99	.78	.23
	III	conc. VI120 VI120	8	2	.004	13	1.72	.91	3.74
	IV	conc. VI120 VI120	5	5	.001	13	1.20	.98	.96
M10	I	conc. VI120 VI120	5	5	.010	27	1.18	.98	1.0
	II	conc. VI120 VI120	2	8	.007	28	.66	.31	.22
	III	conc. VI120 VI120	8	2	.002	21	1.91	1.33	4.00
	IV	conc. VI120 VI120	5	5	.000	13	.99	1.04	.95
M11	I	conc. VI120 VI120	5	5	.009	22	1.3	.80	.88
	II	conc. VI120 VI120	2	8	.003	26	.45	.90	.27
	III	conc. VI120 VI120	8	2	.009	20	1.65	.98	4.18
	IV	conc. VI120 VI120	5	5	.003	13	1.13	.98	.94

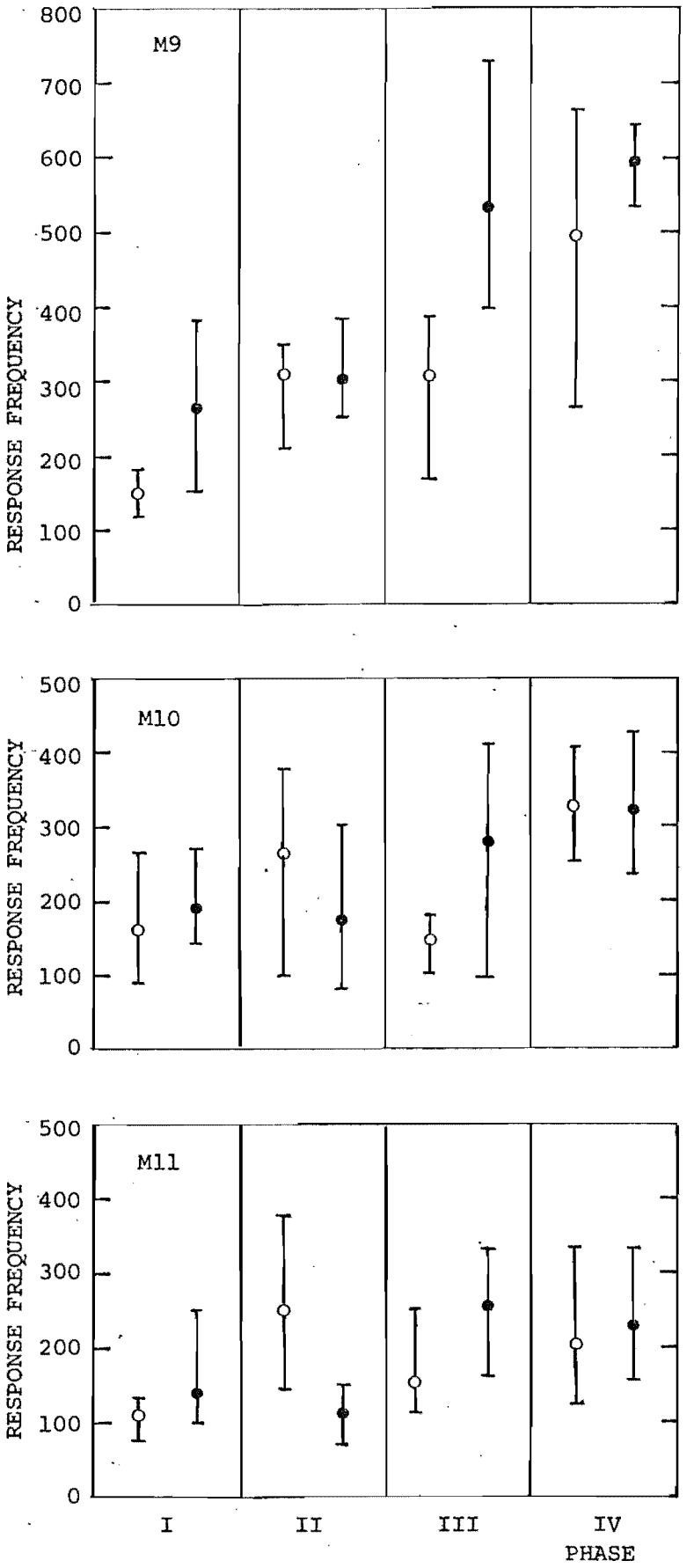


Fig. 14 Response frequency and ranges on the switching key when the food key was green (open circles) and when the food key was red (closed circles). Data are the means and ranges from the last six sessions of each phase.

RESULTS

Table 9 shows the response ratios on the switching and food keys. When reinforcement durations were equal at 5 seconds in phase I and V the switching ratios showed some bias in favour of the green key colour. Response frequencies in figure 14 illustrate the bias which was marked in M9, slight in M11 and not evident in the final baseline of M10. The mean ratio of B_2/B_1 was 1.25 during baselines with a range from .99 to 1.70. When differential reinforcement durations were operating, each switching ratio showed a marked shift. M9 shifted from 1.70 down to .99, M10 from 1.18 to .66 and M11 from 1.3 to .45. Thus in the change from equivalent reinforcement durations to a programmed duration ratio of .25 the B_2/B_1 ratio changed accordingly. In phase III where the durations were reversed so that 8 seconds were available in green and 2 seconds in red a corresponding shift in the ratios occurred. M9 moved from .99 up to 1.72, M10 from .66 up to 1.91 and M11 from .45 up to 1.65. All ratios moved beyond those of the initial baselines and reverted back to lower levels in the final baseline when scheduled reinforcement durations were again equivalent.

Total access to reinforcement was calculated as the product of obtained reinforcement frequency and disperser duration, or $\frac{R_1D_1}{R_2D_2}$ where R is the frequency of reinforcement, D is the duration of the food dispenser presentation, 1 and 2 refer to the presence of green and red key colour.

The relationship between $\log \frac{B_2}{B_1}$ and $\log \frac{R_1D_1}{R_2D_2}$ is shown in table 10. Numbers in table 10 were calculated from only three values of the dependent variable, that is ratios obtained when the dispenser duration ratios were 1.0, .25 and 4.0.

Table 10. Sensitivity (a) and bias (b) values for responses on the switching key and the food key as functions of access to reinforcement. Variance accounted for by the least squares line is also shown.

Subject	Switching B_2/B_1			Food key F_1/F_2		
	a	b	VAC	a	b	VAC
M9	.20	.14	.6816	.05	-.08	.1408
M10	.37	.05	.9756	.51	-.08	.8504
M11	.46	.01	.8094	.04	-.04	.1791

A weaker relationship occurred between switching and reinforcement duration compared to that existing between switching and reinforcement frequency in experiment 1. The relatively large bias toward green in M9 and the low sensitivity of .20 tends to obscure the actual shifts in $\frac{B_2}{B_1}$ ratios as duration was chang ed. M10 and M11 had somewhat higher sensitivities at .37 and .46 with less bias toward green.

Sensitivity and bias values obtained from the food key are also presented in table 10. The sensitivity values of M9 and M11 show a very low relationship to reinforcement duration with the regression equation accounting for very little of the variance. Only M10 demonstrated a positive relationship between food key responding and reinforcement duration with a sensitivity value of .51.

Figure 15 illustrates the insensitivity of food key responding to reinforcement duration in M9 and M11. In baselines I and IV the mean F_1/F_2 ratio for all subjects was .91. In phase II M9 rose from a baseline mean of .68 to .78 when a fall could have been expected. M10 dropped sharply from .98 to .31 and M11 rose from .80 to .90. In phase III when the durations were 8 seconds in green and 2 seconds in red the ratios for all subjects rose above baseline values with a mean ratio of 1.07.

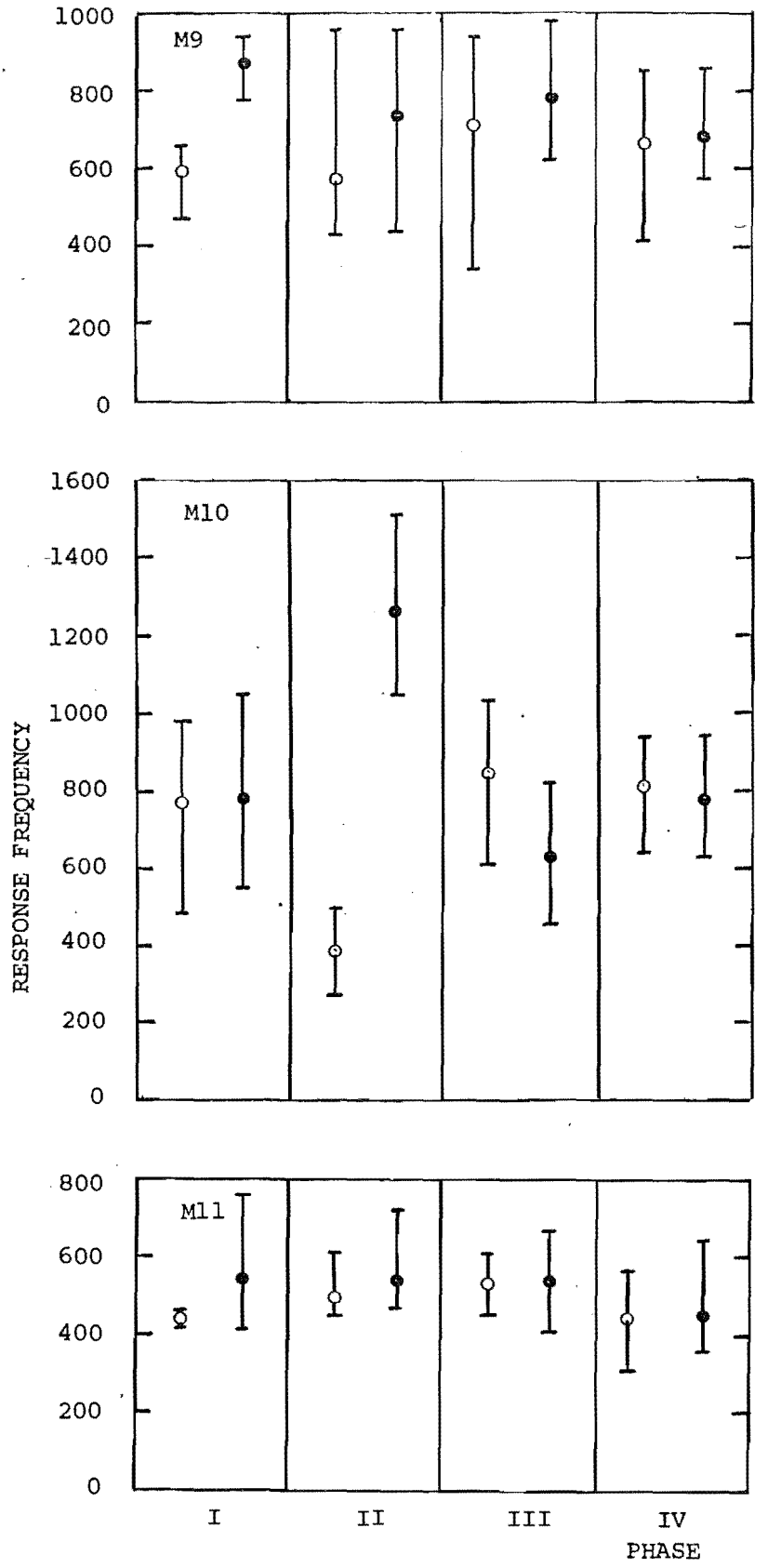


Fig. 15 Response frequency on the food key when the key was green (open circles) and when it was red (closed circles). Data are the means and ranges from the last six sessions of each phase.

A visual comparison of figures 14 and 15 indicates that the switching response was more affected by the changes in reinforcement duration than the food key response. Only M10 showed clear F_1/F_2 changes as direction changed.

DISCUSSION

The data obtained in experiment 3 demonstrated that switching on a VI30 schedule was affected by changes in reinforcement magnitude provided in a conc. VI120-VI120 food schedule. The effect is weaker than might be expected from dispenser durations four times greater than the alternative two seconds.

The lack of a clear relationship between food key responding and reinforcement duration supports earlier research findings that response rates are insensitive to reinforcement magnitude. The extended switching procedure however does provide a weak but definite indication of preference for reinforcement magnitude.

It is clear that the dimension studied (magnitude) bears no simple relation to the switching behaviour of the subjects. While experiment four is satisfactory as an empirical validation of the extended switching procedure and therefore completes the prerequisites for experiment five, the use of the procedure for more detailed psychophysical evaluations of magnitude and other dimensions of reinforcing stimuli is another issue. The effect on switching may have been stronger if immediate discriminatory signals at the onset of dispenser presentation, rather than at the onset of the schedule presentation, had been included and also spatial separation of primary reinforcement supplies; i.e. two or more dispensers to provide visual and spatial cues to aid discrimination.

The preceding experiments have shown that an extended switching schedule provides adequate measures from a single operandum of a subject's preference for both rate and magnitude of reinforcement.

In experiment five these original two parameters, rate and magnitude of reinforcement, with their two respective values were made available as alternative consequences of responding on the switching key. Using the extended switching schedule the issue of 'more food later versus less food sooner; was investigated and additional consequences for switching were programmed to study the possibility of direct control of switching or choice behaviour.

CHAPTER 6

EXPERIMENT 5: CONTROL OF THE CONTROLLING RESPONSE

INTRODUCTION

The extended switching response permits the organism to alter environmental stimuli associated with differential contingencies and provides an indication of preference for the contingencies.

The consequences thus far studied have by design been somewhat removed from the actual switching response, yet if switching is an operant response it seemed likely that it could be controlled by more direct consequences, that is primary reinforcement, punishment or timeout.

Premack and Anglin (1973) suggested that self-denial is a prerequisite for self reward and criticised Banduras's use of punishment for transgressions because of the temporary effects of punishment. In Premack's terms a switching response on the extended switching procedure could be defined as one of high or low probability able to be predicted by scheduling reinforcement rates or durations on the food key. The objectives of an experimental analysis of behaviour are prediction and control (Sidman 1960) so the remaining experiment in the present study sought to investigate the extent of control possible over switching by arranging consequences of a more direct nature.

Reinforcement for switching had to the present point been a transition from one discriminative stimulus to another. An emphasis had been placed on transition not from S^- to S^+ but from S^2 to S^1 with both stimuli signalling some degree of reinforcement availability. If then, the appearance of the food key stimulus was regarded as a reinforcement (and by definition it could not be otherwise) then

termination of the reinforcing stimulus by the organism would go some way toward satisfying Catania's contention that the relevant demonstration of self control must be the termination of the reinforcement by the pigeon rather than by the experimenter (Catania, 1975).

The red or green colour of the food key is a discriminative stimulus in the presence of which responding takes place. As a result of responding, certain contingencies of primary reinforcement are brought into effect and the subject receives food. Responding on the food key varies with the contingencies arranged by the experimenter. As well as being a discriminative stimulus for food key responding, the different key colours exert control over behaviour on the switching key. Except for one condition in experiment 3 switching behaviour was not a prerequisite for reinforcement and the reinforcing event for pecks on the switching was a change in food key colour. (The exception in experiment 3 was the S^- condition in which no primary reinforcement was available.) Thus the onset of a key light, or the transition from one key colour to another may be regarded as the proper reinforcing event (Baum 1974b) and is a transitory event taking so little time as to be practically instantaneous. If the transition as such is regarded as the proper reinforcing event then the action of a subject in removing a food key colour occupying measurable real time would not in itself constitute removal of a reinforcer. By extrapolating the situation transition hypothesis to schedules of primary reinforcement, it may be inferred that it is the appearance rather than the presence of food which is the actual reinforcing event. If that is the case then the preference shown in most research for short frequent rewards rather than larger infrequent rewards is predictable and logical even when a smaller amount of food is consumed overall. In Neuringer's experiments (ibid page 2) where animals continued to respond for access to grain while food was

freely available in the experimental chamber it is suggested that the frequent appearance of food was a stronger reinforcing stimulus than the presence of freely available food.

Thus if situation transition is viewed as the reinforcer and it has no measurable temporal dimension except onset, its termination by either the subject or the experimenter is not possible and any attempt to satisfy Catania's criteria for self control must be restricted to preventing the onset of a preferred situation or reducing the time to onset of a less preferred situation. In terms of the present study this meant a diminished switching response rate during the food key schedule associated with larger delayed reward or increased switching response rate during the small more immediate reward stimulus. Experiment 5 investigated two conditions under which this was likely to occur. The experimenter reinforced switching out of a preferred component and into a less preferred component and punished switching into a preferred component and out of a less preferred component.

During part of the red component on the food key, when an 8 second reward could occur on a VI300 schedule, switching behaviour was punished by turning off all keys and denying reinforcement. During part of the green component when a 2 second reward could occur on a VI75 schedule switching behaviour was reinforced by access to extra grain.

While there were direct and immediate consequences for responding at the switching key, choice behaviour (switching) and food key behaviour were again held as concurrently available options. In other words switching and food key opportunities remained the same.

METHOD

Subjects. Four pigeons M2, M6, M9 and M10 were maintained at 80% plus or minus 15 grams of their free feeding body weight under the same conditions as in experiment 1. All had previous exposures to concurrent procedures with a scheduled switching key.

Apparatus. This was the same as for experiment 1.

Procedure. In phase I subjects were exposed to a Conc. VI75-VI300 schedule onthe food key. Food was available for responding during the green colour on a VI75 schedule and during the red on VI300. Colours could be switched by responding on the white switching key which had a VI30 schedule in effect. In each component the food dispenser duration was 2 seconds. It was predicted on the basis of experiment 1 that the subjects would prefer the VI75 schedule and respond more frequently on the switching key during the VI300 schedule. That is, as the scheduled ratio of R_1/R_2 was 4.0 it was predicted that the B_2/B_1 ratio would approach 4.0.

In phase II the same schedules were in effect but on the VI300 schedule each food reinforcement was increased to 8 seconds. Thus the choice was between a possible 48, two second reinforcements per hour, during green, or 12, eight second reinforcements per hour during red.

The smaller more frequent reinforcement schedule is referred to as 'SF' while the larger but delayed reinforcement schedule is referred to as 'LD'. It was predicted on the basis of experiment 4 that the animals would still prefer the SF schedule but with a reduced B_2/B_1 ratio due to the small effect of the larger reinforcement magnitude.

Table 11. Summary of schedules and conditions with switching key ratios B_2/B_1, food key ratios F_1/F_2 and ratios of obtained total access to reinforcement R_1D_1/R_2D_2. Steady state data are shown in the columns slope and sessions.

Pigeon	Phase	Schedule	Reinf. duration (secs) G	Reinf. duration (secs) R	Slope	Sessions	Food key additions	B_2/B_1	F_1/F_2	R_1D_1/R_2D_2
M2	I	conc. VI75 VI300	2	2	.006	19	-	4.68	2.15	4.14
	II	conc. VI75 VI300	2	8	.008	18	-	1.94	1.80	.71
	III	conc. VI75 VI300	2	8	.007	13	Line signals	2.55	1.50	1.04
	IV	conc. VI75 VI300	2	8	.040	13	Lines + consequences	.80	1.44	.82
	V	conc. VI75 VI300	2	8	.006	16	Line signals	1.61	1.58	.90
	VI	conc. VI75 VI300	2	8	.001	15	-	3.00	1.85	.77
M6	I	conc. VI75 VI300	2	2	.009	17	-	2.93	2.58	3.39
	II	conc. VI75 VI300	2	8	.004	20	-	2.72	1.35	.90
	III	conc. VI75 VI300	2	8	.003	13	Line signals	1.66	1.20	.93
	IV	conc. VI75 VI300	2	8	.013	15	lines + consequences	1.50	1.38	.77
	V	conc. VI75 VI300	2	8	.018	13	Line signals	1.42	1.30	1.11
	VI	conc. VI75 VI300	2	8	.001	18	-	2.79	1.84	1.20
M9	I	conc. VI75 VI300	2	2	.001	23	-	3.43	1.85	3.5
	II	conc. VI75 VI300	2	8	.003	13	-	1.45	1.54	.97
	III	conc. VI75 VI300	2	8	.011	13	Line signals	1.13	2.08	1.0
	IV	conc. VI75 VI300	2	8	.028	36	Lines + consequences	.67	.80	.60
	V	conc. VI75 VI300	2	8	.006	14	Line signals	1.36	1.21	.90
	VI	conc. VI75 VI300	2	8	.006	19	-	1.95	2.84	1.20
M10	I	conc. VI75 VI300	2	2	.001	19	-	3.37	2.82	3.86
	II	conc. VI75 VI300	2	8	.003	15	-	1.57	1.93	1.0
	III	conc. VI75 VI300	2	8	.012	15	Line signals	.90	1.35	1.0
	IV	conc. VI75 VI300	2	8	.002	33	Lines + consequences	.78	.79	.62
	V	conc. VI75 VI300	2	8	.007	13	Line signals	.75	1.22	.97
	VI	conc. VI75 VI300	2	8	.005	28	-	1.44	1.56	1.16

In both SF and LD schedules the maximum possible access to food was 96 seconds per hour in each component. During green, 48 x 2 seconds per hour and during red 12 x 8 seconds per hour. Expressed as 'rate of reinforcement time' (Ten Eyck 1970) the animals were able to gain 1.6 seconds of reinforcement per minute in each of the concurrent components. Because of the weaker effect of magnitude seen in experiment 4 it was predicted that the subjects would still prefer the SF schedule but with a reduced B_2/B_1 ratio.

In phase III conditions remained the same but additional signals were superimposed on the coloured food key. Phase III was a prelude to the next phase when the signals were designed to become discriminative stimuli. The added signals were two black lines which alternated every 90 seconds between horizontal or vertical. The 90 second intervals were programmed by a timer and were independent of any other events occurring, regardless of key colour or the animals' behaviour. The lines appeared continuously on the food key except during reinforcements when all keys were unlit. Switching responses were recorded in each signal.

In phase IV the food and switching schedules remained the same but some of the switching behaviour was subject to additional consequences. If the animals responded to remove the SF condition when the lines were vertical then extra food reinforcements were provided. Responses on the switching key were not only followed by a change in food key colour on a VI30 schedule but also resulted in 3 seconds access to food on a VI30 schedule.

But if the line signals on green were horizontal then no additional reinforcements were available and the only consequence was the usual VI30 changeover to red.

The division of the green (SF) component into two sub-components, one with 90 seconds of vertical lines and one with 90 seconds of horizontal lines was in effect a multiple schedule within a concurrent component and is described as a multiple VI30-extinction schedule (Mult. VI30-Ext.). The VI30 and Ext. refer only to the additional consequences as the usual consequences of switching continued simultaneously and independently. In multiple schedules the duration of stimuli are controlled by the experimenter, they occur sequentially and the schedule components are not independent of one another. In the present case they were alternated every 90 seconds but the actual times varied because a combination of a colour plus a particular line orientation could be changed to another colour plus the same line orientation.

The red (LD) schedule was similarly divided into two sub-components with the same horizontal or vertical line signals. A multiple schedule was programmed within the LD schedule but in this case the vertical lines indicated no additional consequences. Instead, the horizontal lines indicated that a five minute timeout followed every 5th peck on the switching key. During the timeout (TO) all lights, operanda and schedules were inoperative and no reinforcements, or changeovers, could be gained. Only the 90 second line signal timer continued independently but of course the lines did not appear on the food key. After the timeout period all schedules resumed where they had stopped but by then the line signals had changed positions a number of times and could be either horizontal or vertical.

If a timeout producing peck also changed the food key colour then the new colour resumed after the timeout period, as did the new food schedule. Similarly if during green a successful switching peck also produced additional food, the new colour resumed after the reinforcement. The rather complex procedure is presented below in Table 12.

Table 12. Summary of schedules operating in phase IV. 'H' indicates that the horizontal lines were in the coloured food key, 'V' indicates that the lines were vertical.

FOOD KEY		SWITCHING KEY	
Stimuli	Response consequence	Stimuli	Response Consequence
Green + H	VI75 (2 sec. food)	white	VI30 → food key change
Green + V	VI75 (2 sec. food)	white	VI30 → food key change + VI30 → 2 sec. food
Red + H	VI300 (8 sec. food)	white	VI30 → food key change + FR5 → (T.O.)
Red + V	VI300 (8 sec. food)	white	VI30 → food key change

In phase V the usual SF and LD concurrent food schedules continued with switching on a VI30 schedule. The line signals remained but the additional consequences of switching behaviour were removed. Phase V thus returned to the conditions of phase III.

Phase III, IV and V constituted a baseline, treatment, baseline module within the larger experiment. The dependent variable of interest was the rate of responding on the switching key calculated as frequency divided by time in the presence of each line stimulus. That is, rate of response in the presence of the vertical or horizontal lines. It was predicted that: there would be an increase in rate of responding on the switching key when the Green+V stimuli were on the food key in phase IV : there would be a decrease in rate of responding on the switching key when the Red+H stimuli were on the food key. Phase III and V were baselines for detecting changes in phase IV.

In phase VI the line signals were removed and the choice reverted back to a green or red key colour with SF and LD schedules respectively. Phase VI was therefore identical to phase II which was essentially the original baseline.

The purpose of phase I with equal 2 second reinforcement durations was to check that the conclusions from experiment four were valid when unequal concurrent schedules were used. In experiment 4 the schedules were Conc. VI120-VI120 and unequal reinforcement duration exerted a small effect on B_2/B_1 ratios. In experiment 5 the schedules were unequal at conc. VI75-VI300 and it was appropriate to test the effect of the unequal reinforcer durations. It was predicted that B_2/B_1 would lessen but still remain above 1.0.

Dependent Variables. The major dependent variable was the frequency of response on the switching key presented as the ratio of frequency in red to frequency in green, or B_2/B_1. While B_2/B_1 was

recorded and presented in table 11, the variable of interest in phases III, IV and V was the rate of response on the switching key during each component of the multiple schedules, that is frequency divided by time in the stimulus. The ratios of the rates are shown in table 12. If the switching response is subject to the Law of Effect it was predicted that during SF (green) with additional reinforcement for switching, the ratio of rate during vertical lines to rate during horizontal lines, or $\frac{\text{RateV}}{\text{RateH}}$, would increase in phase IV. During the LD (red) schedule with timeout for switching, the ratio of $\frac{\text{RateH}}{\text{RateV}}$ would decrease.

The neutral effects of the vertical or horizontal line stimuli were replaced in phase IV by contingencies which were predicted to be reinforcing or punitive. The choice of schedules, VI30 for additional reinforcement and FR5 for timeout was to some extent a choice of expediency for demonstrating the either-or effects rather than for parametric precision. In other words, except for investigating the susceptibility of the switching operant to specific consequences and to incorporate the process into the existing system, the choice of the two new schedules was arbitrary.

Sessions ended when 30 reinforcements had been gained from the food key and the steady state criteria of experiment 1 was used, except in phases III, IV and V when the steady state criteria of .01 or less slope was applied to responding in the multiple components as these were the measures of primary interest. Because the criteria of .01 or less is regarded as an indication of *a* steady state rather than *the* definitive final steady state, the phase was ended when behaviour in both elements had reached slopes meeting the criteria although both slopes were not necessarily attained on the same day. Hence in table 12 the reinforcement signal slope of M10 in phase IV had risen to .031 and the timeout signal slope of M9 in phase IV had risen to .014. Both had previously reached a steady state with slopes .01 or below.

In table 11 the slopes during phases III, IV and V are presented but were not used for steady state criteria.

RESULTS

The subjects pecked at the food key and the switching key in stable and consistent patterns typical of VI schedules. As in previous experiments food key pecks were interspersed with switching pecks. A noticeable but not recorded feature of all the experiments was that each subject developed a rhythmic pattern of responding, perhaps 3 food key pecks followed by 1 switching peck and repeating the pattern.

The results are presented in two sections. Firstly in terms of the general switching response and secondly in terms of the switching rates during phase III-V. Minor attention is given to the food key response in experiment 5. The switching response was the main focus of attention as a manipulable indicator of choice between less but frequent reward or more but less frequent reward.

The feasibility of the switching response as an indicator of choice was considered in the overall view of the results while its susceptibility to manipulation was considered more specifically in phases III-V.

Table 11 shows the ratios B_2/B_1 of the switching response and figure 15 shows the frequencies from which ratios were derived. B_2 was the response frequency in the red key colour (LD schedule) and B_1 was the frequency of response in the green (SF schedule). In three subjects it is apparent in all phases except IV that more responses occurred in B_2 with subsequent ratios higher than 1.0. M10 was the exception with a .90 ratio in phase III and a .75 ratio in Phase V. B_2/B_1 ratios were highest in phase I when the concurrent food schedule was simply conc. VI75-VI300 with equal reinforcement durations. B_2/B_1 ratios in this

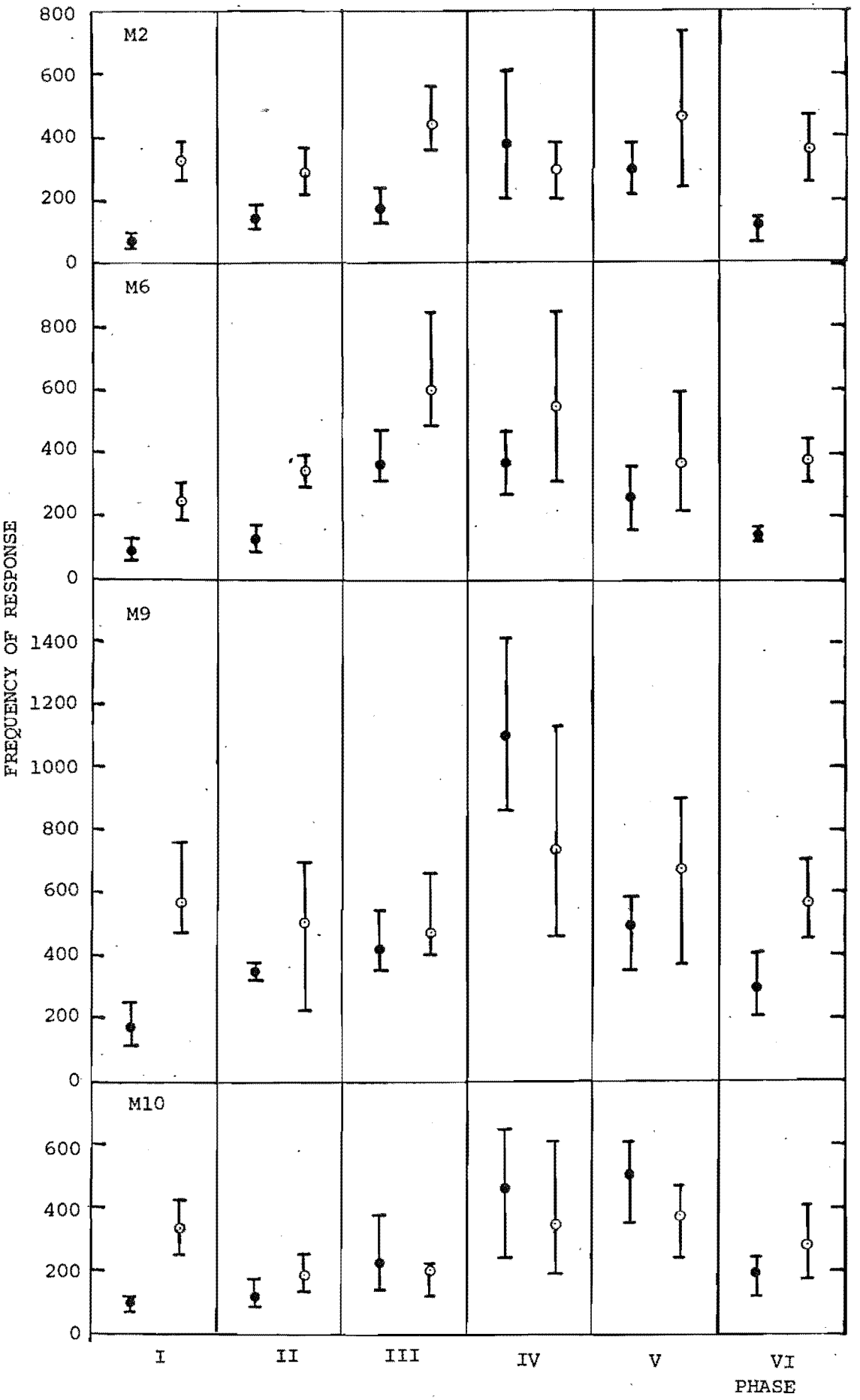


Fig. 16. Response frequencies on the switching key during the green food key (closed circles) and during the red food key (open circles). Data are the means and ranges from the last six sessions of each phase.

condition were nearer to the ratios of reinforcement obtained than were the F_1/F_2 ratios also shown in table 11.

In phase II when the food schedules changed to SF and LD the ratio B_2/B_1 decreased in all subjects indicating a shift in the degree of preference for the SF schedule. The shift coincided with the introduction of the larger reward during the VI300 food component and was due to reductions in B_2 responding. M6 was the exception with an increase in B_2 and B_1 but still changing the ratio from 2.93 to 2.72. A corresponding but smaller shift occurred in the ratios F_1/F_2 indicating that food key frequencies were sensitive to changes in reinforcement magnitude.

When the line signals were introduced in phase III some variation occurred in B_2/B_1 ratios but in three of the four subjects they remained above 1.0. The ratio of M2 increased from 1.94 to 2.55 due to a B_2 increase. The ratio of M6 decreased from 2.72 to 1.66 due to a substantial increase in B_1 and B_2. The ratio of M9 decreased from 1.45 to 1.13 due to an increase in B_1 and a decrease in B_2. The fourth subject M10 decreased its ratio from 1.57 to .90 due to a relatively large increase in the SI component (B_1 responding).

Although the introduction of line signals resulted in some variation the B_2/B_1 ratios in three quarters of the subjects indicated that the SF component was still preferred.

In phase IV when the additional consequences for responding were programmed, the animals produced low B_2/B_1 ratios. In figure 16 it is seen that the B_1 frequencies rose above those of B_2 resulting in ratios of below 1.0, except for M6 whose response frequencies were relatively unaffected. M6 did however show a small B_2 decrease and the ratio fell slightly from 1.66 in phase III to 1.50 in phase IV. In phase IV the ratio of reinforcements obtained calculated from the product of frequency and duration fell to low levels of .82, .77, .60 and .62 for subjects M2, M6, M9 and M10 respectively. It should be remembered that the

reinforcement frequencies refer only to those obtained at the food key and not to the additional reinforcements scheduled at the switching key.

F_1/F_2 ratios also dropped to their lowest levels in three out of four birds during phase IV. Again M6 did not conform to the pattern of discrimination shown by the other three subjects. Reference to table 11 shows that the F_1/F_2 ratios of M6 showed only small variations in phases III-V.

The reversal of B_2/B_1 in three out of four subjects exceeded the prediction that the ratios would merely decrease. The arbitrary choice of extra VI30 reinforcements during part of the SF schedule and FR5 leading to timeout in part of the LD schedule was designed to investigate the possibility of controlling the switching response by direct consequences. In phase V which was a return to phase III conditions, three of the four subjects showed B_2/B_1 ratios of more than 1.0 demonstrating a preference for the SF schedule due mainly to a decrease in B_1 responding. M10's switching ratio remained low at .75 suggesting a continued preference for the LD schedule but its F_1/F_2 ratio demonstrated the reverse with a rise from .79 in phase IV to 1.22 in phase V.

In phase VI when the choice was between SF and LD and the line signals were removed all subjects returned to preferences for SF. B_2/B_1 ratios and frequencies were similar to those occurring in phase II which had the same schedules and stimuli. B_2/B_1 ratios did not reach the high values of phase I indicating that the larger 8 second reward maintained its influence. F_1/F_2 ratios also rose to levels comparable with phase II, although the F_1/F_2 ratio of M9 rose well above the original phase I ratio.

The preceding analysis of switching behaviour in experiment 5 indicated that the extended switching procedure may be used to demonstrate preference for SF or LD conditions when both the frequencies and durations of reinforcements are unequal. Three of the four subjects, M2, M6 and M9, showed a definite pattern of conforming to the complex

combination of contingencies operating in experiment 5. The remaining subject M10 demonstrated only partial support for the predictions.

In summary the original preference for more frequent reinforcement was demonstrated in phase I on the switching key and to a lesser extent on the food key.

Table 13. Phase III, IV and V. Ratios of response rates on the switching key in each multiple component. During VI75 (green) additional reinforcement for switching occurred during vertical signals, no additional reinforcement during horizontal signals. During VI300, timeout for switching occurred during horizontal signals, no added consequence during vertical signals. The columns headed slope refer to the steady state of the responding.

Pigeon	Phase	Slope in reinft. signal	Slope in timeout signal	green $\frac{\text{rate in V}}{\text{rate in H}}$	red $\frac{\text{rate in H}}{\text{rate in V}}$
M2	III	.000	.004	.95	1.23
	IV	.010	.003	.88	.61
	V	.005	.006	1.18	.94
M6	III	.004	.006	.97	1.3
	IV	.001	.002	.88	.47
	V	.003	.001	.96	.97
M9	III	.009	.001	1.12	.94
	IV	.009	.014	1.25	.38
	V	.003	.002	1.06	1.07
M10	III	.009	.009	.89	1.06
	IV	.031	.006	.78	.63
	V	.009	.002	1.13	1.12

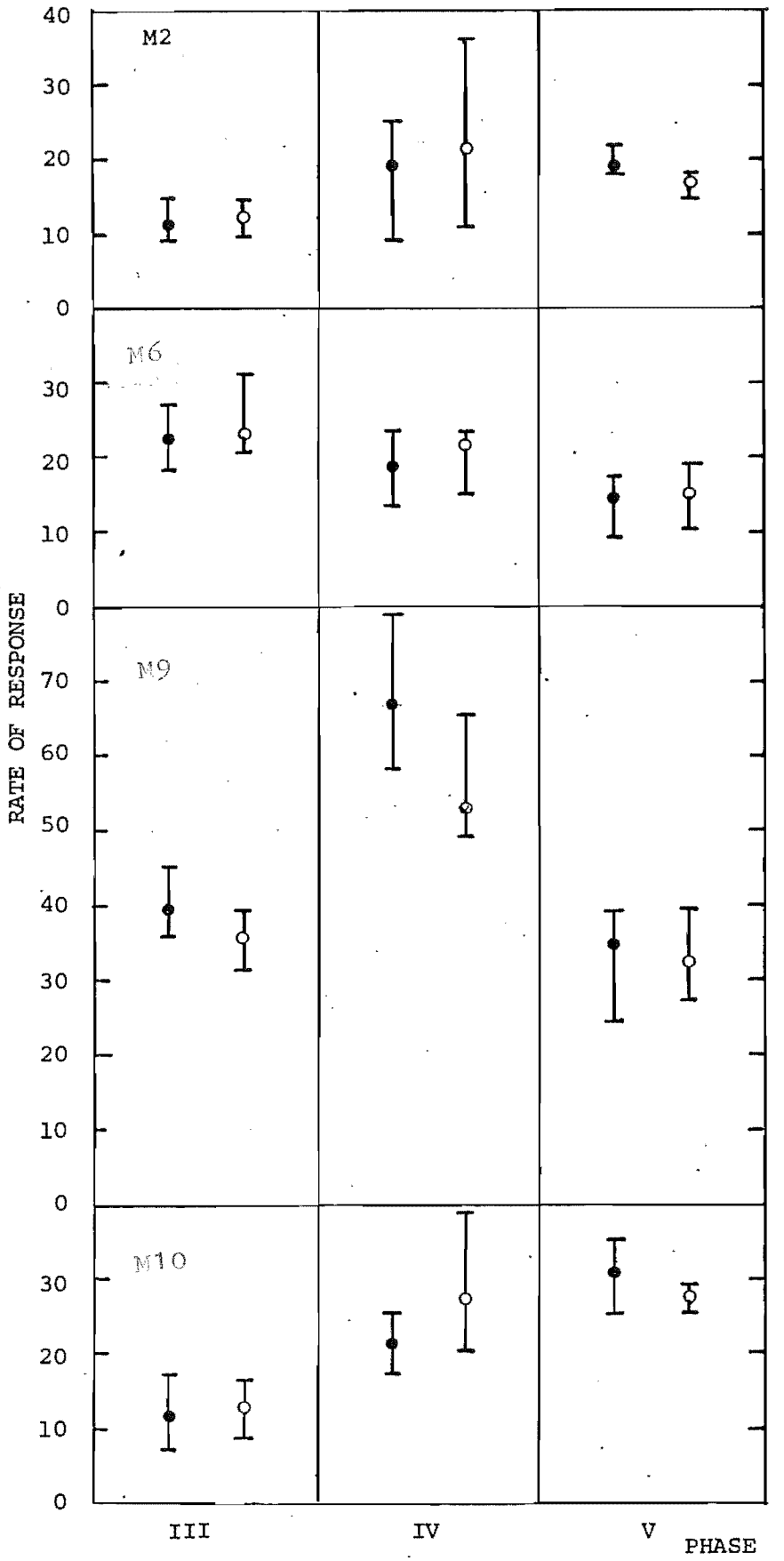


Fig. 17 Switching response rates in each multiple component of the VI75 food schedule (green key colour). Responding in phase IV produced additional reinforcement (closed circles) or no additional reinforcement (open circles). Data are the means and ranges of the last six sessions.

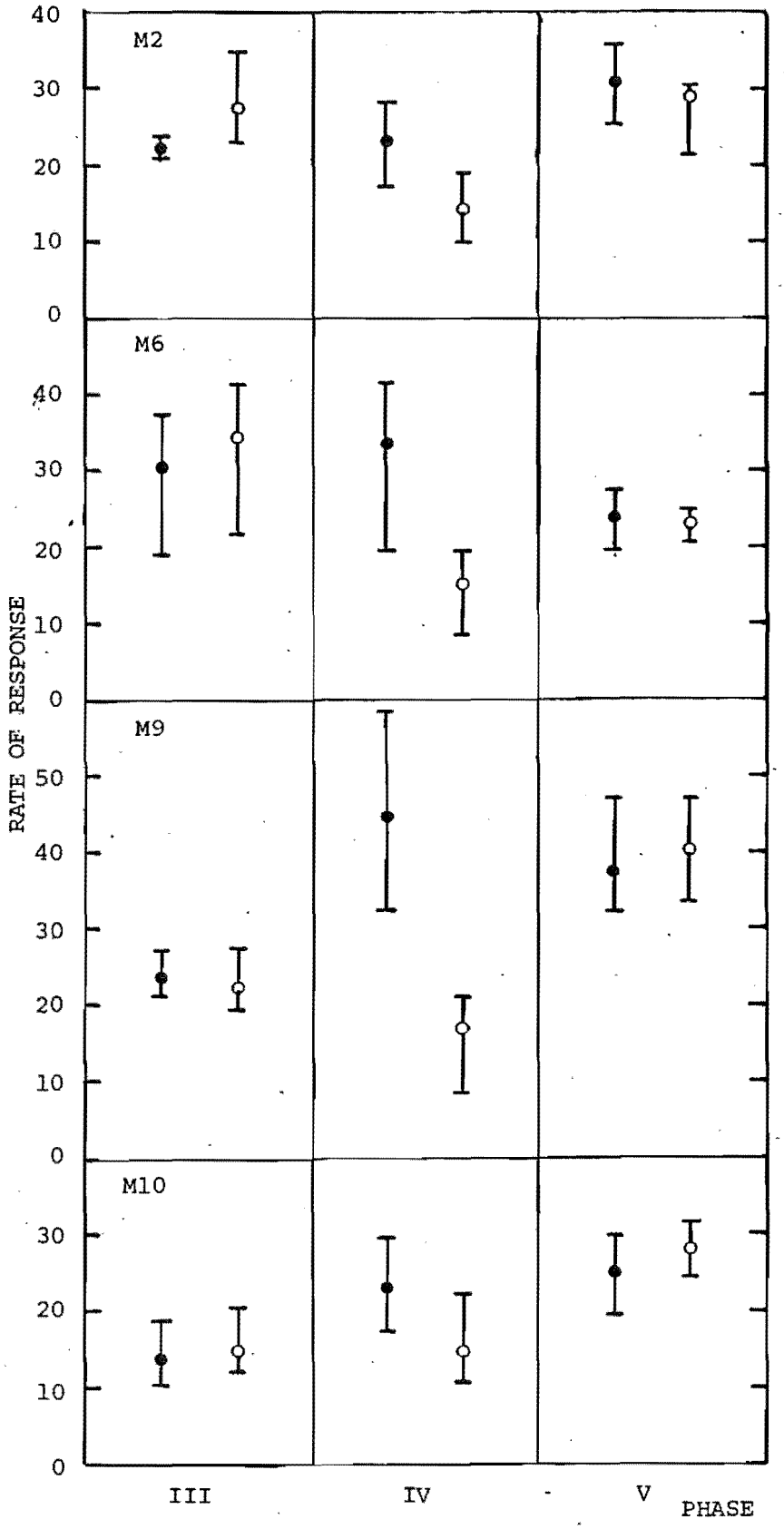


Fig. 18 Switching response rates in each multiple component of the VI300 food schedule (red key colour). In phase IV responding produced (timeout) (open circles) or no additional consequences (closed circles). Data are the means and ranges of the last six sessions.

Figure 16 illustrates the response rates in green from which the ratios in table 13 were derived. Rates in the horizontal signal were divided by rates in the vertical signal. During phase IV extra reinforcement was available during the signal so a ratio rise was predicted. Surprisingly the only subject to follow the prediction was M9. Ratios fell in the three other subjects. At baselines the horizontal and vertical rates were near equivalent. However, in M2, M9 and M10 rates rose in both components of the multiple schedules.

Figure 17 illustrates the response rates in red from which the ratios in table 13 were derived. Rates in the horizontal signal were divided by rates in the vertical signal. During phase IV timeout followed switching behaviour during the horizontal signal so a fall in phase IV ratio was predicted. All subjects followed the prediction. Ratios fell to low levels and returned to near baseline levels in phase V. The main reason was a drop in rates in the timeout signal although a contrasting rise in the neutral signal rates occurred in M9 and M10.

The effects of timeout were more specific than the effects of added reinforcement which resulted in a general rate rise.

CHAPTER 7

GENERAL DISCUSSION

In general a higher sensitivity to both frequency and duration of reinforcement was seen in switching performance than in food key performance.

In experiment 1 switching performance was monotonically related to the frequency of reinforcement obtained on the food key and the measures of sensitivity obtained from the generalised matching law were higher in each subject when switching ratios were used as the dependent variable. In experiment 4 when the independent variable was reinforcement duration, the functions obtained from the generalised matching law were weak in terms of sensitivity but the switching performance provided a better indication of preference than the food key.

Experiment 5 demonstrated that the switching ratios B_2/B_1 were reliable indicators of preference when unequal reinforcement rates and unequal reinforcement durations were combined and also that switching performance was sensitive to experimental manipulations.

Since Findlay's original experiments on switching few studies have specifically investigated the switching response an an operant behaviour.

A series of experiments by Tustin and Davison (1979) placed the switching or changeover response on interval schedules and investigated the effects of reinforcement at the food key. Performance on the switching key in the present study showed some similarities to changeover performance in the Tustin and Davison studies. The present study employed response ratios as the dependent variable while Tustin and Davison used time proportions, recorded as the time elapsing between the first peck on the changeover key and the first peck on another key. Nevertheless the functions between the logarithms of whichever dependent

variable was used and the logarithm of the reinforcement ratios, were monotonically related in each study. Sensitivities in the present study (experiment 1) ranged from .72 to 1.03 with a mean of .90 while Tustin and Davison's sensitivities in one component ranged from -.56 to -1.22 with a mean sensitivity of -.85.

In the present study changeover or switching performance was expressed as B_2/B_1 and the exponent or perfect matching was therefore 1.0 whereas Tustin and Davison used the reverse calculations and the perfect matching exponent was -1.0. Tustin and Davidson's sensitivities in the presence of a green key colour were considerably lower than in a red colour.

Experiments 2 and 4 demonstrated that factors other than reinforcement frequency affected switching performance. In experiment 4 with equivalent food schedules but differential reinforcement durations the effect of reinforcement frequency was held constant and the subjects demonstrated preference for the larger reinforcement. The results of experiment 4 were significant in that preference for larger reward was demonstrated on a single operandum without providing additional discriminative stimuli on the food key. That is, the green or red key colour was correlated with the combined stimulus for frequency and duration and the effects were verified in experiment 5. The main contributing factor to the successful demonstration of preference for larger reward was considered to be the fulfilment of Neuringer's (1967) prerequisite - that reinforcement magnitude should be contingent on responding. In experiment 5 where unequal frequency of reinforcement and unequal duration of reinforcement were both scheduled simultaneously, the transition from phase I to II showed that switching performance was affected by both variables. The ratio of B_2/B_1 as an indicator of responding to change food key schedules was reduced when the schedules were altered from a choice of small frequent reward versus small delayed reward to small frequent

reward versus large delayed reward.

Another factor affecting the function between switching performance and reinforcement was the requirements of the changeover schedule. In experiment 2, variation of the switching schedule (VI15, VI60, VI120, VI180) altered switching performance to the extent that sensitivities were drastically lowered. Neither an analysis in terms of reinforcement ratios nor in terms of switching schedules was sufficient to explain the switching performance exhibited in experiment two. Experiment 2 was valuable in so far as it demonstrated the need to verify the reliability of the extended switching procedure in further experiments before engaging in specific experimental manipulations. For example the first phase in experiment 5 was in effect a pre-baseline pilot phase to verify that B_2/B_1 ratios followed the predictions made from experiment 1. Once verified it was possible to proceed with the assumption of switching sensitivity empirically established.

It has been suggested that temporal separation of components of a concurrent schedule would decrease the sensitivity of an organism's performance (Herrnstein 1970). In the present study each food component was usually separated by an average of 30 seconds - the minimum length of the switching schedule and although no comparison was made between switching schedules of VI0 and VI30, the temporal separation of components by VI30 still permitted reliable sensitivity measures to be assumed.

Experiments by Stubbs and Pliskoff (1960) suggest that sensitivity of switching performance declines as the switching requirements increase. They employed fixed ratio requirements of FR1, FR2, FR5, FR10 and FR20 and at higher requirements the sensitivity of switching performance was lessened. At the two lowest fixed ratios no significant effect on switching performance occurred. Experiment 2 of the present study systematically varied the switching requirements but was inconclusive in

attempts to demonstrate a clear relation between sensitivity and temporal separation of components. A possible explanation lies in the complexity of interactions between schedules when a switching requirement exceeds that of one of the food schedules. Consider a hypothetical situation where an animal has just switched into a red component, the switching schedule is VI120 and the green (switched out) component is VI60. Then on average a reinforcement would be available in green, well before a changeover to green occurred. On a change to green there is a high probability that the first food key peck after the COD will produce food. If however the switching schedule is VI30 and the green component VI180 a reinforcement is unlikely to be available on the food key until an average of 150 seconds has elapsed after a changeover to green.

Again if the switching schedule was VI60 and the green component VI120 then after a switch to green there should be a further delay averaging 60 seconds to obtain primary reinforcement.

If the above three conditions are considered in theoretical isolation each forms a type of chained schedule expressed respectively as

Chain VI120(VI0)

Chain VI30 (VI150)

Chain VI60 (VI60)

where the initial link is the length of the switching schedule and the terminal link the remaining time to reinforcement in green. In the terminal link (VI0) the delay to reinforcement is limited only by the COD but probability of reinforcement increases as the time on the switching schedule lengthens. If in each of these situations one considers the fact that the subject may also respond to the existing red key colour and its associated schedule, the ability of the animal to discriminate must be questioned or empirically verified. Experiment 2 did not achieve that aim. With procedural modifications an analysis of switching performance may be possible using the concept of delay to reinforcement

advocated by Squires and Fantino (1971). Although their model was developed for concurrent chains procedures it may be applicable to the extended switching procedure. The model states that preference for a terminal-link schedule depends on the reduction in T (overall time to reward) correlated with entry into that terminal link. In experiment 2 of the present study switching responses in some combinations of schedules reduced the delay to local reinforcements but increased the delay to overall reinforcements. A change in procedure is however necessary before Squires and Fantino's model could be utilised in the extended switching procedure.

The study by Stubbs and Pliskoff (1969) where changeover requirements were studied, demonstrated a relation between interchangeover times and changeover requirements. Interchangeover time ICT was calculated by dividing the time in the presence of a key stimulus by the number of changeovers during that stimulus. They found that ICT's increased as the fixed ratio requirements to changeover increased. Exponents were high, ranging from 1.40 to 2.04. A similar increase occurred in experiment 2 of the present study and is readily explained by the constraints on switches (changeovers) imposed by the VI schedules. ICT's in experiment 2 were computed and are presented in table 14.

Reading from left to right the ICT's decrease as the switching schedule requirements decrease to VI15, indicating a definite and predictable relationship. Reading down the columns a small relationship exists between food key schedules and ICT's. Tustin and Davidson found a relationship between ICT's and reinforcement rate when subjects could switch with one response (FI0). In table 14 the correlations between ICT and scheduled reinforcements per minute are shown for each value of the switching schedule. Correlations varied between .38 and .81 but were generally not high. There was a tendency however for low ICT's to be

Table 14. Interchangeover times in experiment 2. Columns indicate the requirements of the switching schedules. Rows indicate the requirements of the food key schedules. Correlation coefficients between ICT's and scheduled reinforcements per minute are shown for each switching requirement.

Subject	Food schedule	Switching Schedule			
		VI180	VI120	VI60	VI15
M6	VI600	2.45	1.58	.99	.29
	VI180	2.96	2.21	.93	.29
	VI120	2.73	-	-	-
	VI90	3.94	1.68	1.19	.31
	VI66.67	3.26	3.48	1.15	1.80
	Correlation	.70	.38	.81	.76
M7	VI600	2.73	1.71	.99	.24
	VI300	3.51	1.26	1.01	.26
	VI120	-	-	-	.25
	VI75	2.73	2.45	1.00	.35
	VI66.67	3.51	1.97	1.06	.55
	Correlation	.75	.076	.43	.67

associated with high food key requirements and higher ICT's to be associated with more generous reinforcement schedules. That is, given the constraints imposed by the switching schedule, the time to effect a changeover was shorter in the less generous food schedules and longer in the more generous food schedules. ICT's were small when the VI15 switching schedule was operative (mean ICT = .48) and increased as the schedule increased. At VI180 the mean ICT was 3.09. The stable responding engendered by the VI switching schedules usually resulted in a switch occurring almost as soon as it was made available by the schedule. Therefore the frequency of reinforcement in the food schedules should have exerted little effect on the ICT's and it is perhaps surprising that even a small relationship existed between food schedule and inter-

changeover times. Fixed ratio requirements as employed by Stubbs and Pliskoff tend to bring the consequences forward in time as the animal responds faster but VI schedules as used in the present study do not. Also relevant is the Stubbs and Pliskoff procedure, where the first peck on the switching key removed the food key stimulus. The faster the subjects responded on the switching key the sooner the food key opportunities were reinstated. In the present study food key opportunities and opportunities to switch were not removed as the two schedules were independent.

Some studies have reported increases in main key (food key) responding and/or decreases in switching performance as changeover requirements increased (Pliskoff 1971, Fantino, Squires, Delbruck and Peterson 1972). In experiment 2 low food key frequencies were recorded in the larger component of the Conc. VI600-VI66.67 food schedule only during the VI15 switching schedule. At VI15 they were 122 for M6 compared to a mean of 321 during the other VI600 components, and 158 responses by M7 compared to a mean of 320 in the other VI600 components. The lowest switching frequencies also occurred during the same phase but of course during the shorter VI66.67 component. Switching frequencies by M6 during that component were 18 compared to a mean of 121 during the other VI66.67 components and by M7, 72 responses where the mean in the others was 252. Overall main key frequencies were not systematically affected by changes in the switching schedule and the effect on switching has been discussed in chapter 3.

In the present study responding persisted even when it meant a changeover to an ungenerous food schedule and delayed both local or overall reinforcement rates. A similar finding by Tustin and Davison led to their hypothesis that animals sample alternatives at a rate dependent on the present rate of reinforcement. They designed an

experiment in which extinction was one of the components of a concurrent food schedule. They found that the richer the food component the less the rate of changeover. Experiment 3 in the present study demonstrated that without the inherent advantages of switching implicit in concurrent schedules, the switching response declined to extinction levels in one subject, but a limited number of switching pecks were made by another. It may be debated whether an organism switches into a component or out of a component and if such a purpose is ascribed to the organism then reasons may be postulated such as curiosity, arousal etc. Catania's functional explanation that an inverse relation exists between a reinforcement rate and the rates of other responses not earning that reinforcement (Catania 1969) appears to account for the difference in ratios of B_2/B_1 when reinforcement is available in unequal schedules but the persistence of the switching response is perhaps to be explained in phylogenetic rather than ontogenetic contingencies until a better explanatory function is found.

The switching response has formal similarities to other methods used in the experimental analysis of behaviour. As a measure of choice it is related to the concurrent chains procedure where initial link responses are distributed in the same proportions as terminal link reinforcers. It is also similar to the Wyckoff observing response insofar as information is provided as a result of responding, and like the observing response it is a measure of preference. In the same manner as the advance-key response of Honig et al. (1972) the extended switching procedure demonstrates a choice between discriminative stimuli with varying degrees of value rather than a discrete choice between S^+ and S^-.

Although these formal similarities exist, the switching response differs from concurrent chains procedure in that the organism remains in a terminal link situation and does not normally enter a stimulus indicating no reinforcement availability. In other words, the choice is between two continuously available reinforcement probabilities rather than the concurrent-chains procedures where signals indicate no reinforcement or two mutually exclusive alternatives. The pigeon in concurrent-chains procedures normally has to respond in the initial link to obtain any primary reinforcement but in the extended switching procedure, responding on the switching key is not a prerequisite for primary reinforcement. It differs from the observing response in that it does have direct effects on the probability of reinforcement whereas the observing response led only to information about the contingencies already in effect. The major advantage of the extended switching response is its verification as a discrete response, available on a single operandum and subject to schedules and contingencies used in the experimental analysis of behaviour.

Experiment 5 demonstrated that switching on an extended schedule was subject to direct control by added contingencies. Further studies are necessary to tease out the effects of the values of the variables used but the basic axiom that switching is a manipulable operant has been established. As an operant that provides a suitable measure of preference for reinforcement contingencies it may then be applied to theoretical issues such as self control.

An experimental analysis of behaviour diminishes the importance of a notion of "self" and seeks functional relations between observable events. Skinner's analysis of self control is emphasised in the present study where a relationship is postulated between a controlled and a controlling response. The analogy of the smoker who leaves cigarettes at home is an example of a controlling response (leaving the cigarettes)

manipulating the variables of which the controlled response (smoking) is a function. The present study has been concerned with the situation where the controlling response and the controlled response are concurrently available. In this study the controlled response was seen as the food key peck. There is sufficient research on concurrent schedules to assume that food key responding is controlled by the discriminative stimuli available. In the present study these were red and green food key colours. The switching key was seen as the controlling response insofar as it was free to manipulate the variables of which food key responding was a function.

In Rachlin and Green's model, discussed fully by Navarich and Fantino (1976), the controlled and controlling responses (terminal link and initial link in concurrent chains) were temporally separated. In the Rachlin and Green model, subjects made a commitment to a terminal link which provided opportunity to work for small frequent reward or large delayed reward. At a choice point where options were concurrently available the animals usually chose the small immediate reward but if required to commit themselves prior to the choice point, they frequently chose the larger delayed reward. The commitment however was irreversible and the choice then became one of reward or no reward. After reinforcement the initial links were reinstituted.

In the present study choice and commitment were simultaneously available. Commitment was in most experiments limited to 30 seconds on average by the switching schedule and the animal could at any time respond on the switching key, that is, perform the controlling response. At the same time the animal could respond at the food key, that is perform the controlled response. (In experiment 2, the pigeon committed its behaviour to be controlled by the green or red contingencies for 15, 60, 120 or 180 seconds.) Generally when a peck produced the red key colour

the animal was forced to remain in the presence of the red key for an average of 30 seconds. Thus a successful switching response was a commitment to spend a period of time in the presence of a particular contingency of reinforcement. If the switching response or the food key response was subject to prerequisites such as turning off one key until requirements had been met on the other (viz. Stubbs and Pliskoff 1969) then the choice would have been constrained and a situation like the concurrent chains schedule would have been in effect. In the present study the animal was not functionally removed from contingencies operating on either key. Therefore the prior commitment could be broken at any time, limited only by the VI30 switching schedule constraints. Unlike a concurrent chains schedule the commitment to a colour was not irreversible until food key requirements had been met as the animal was still free to choose green again.

At any point the animal was free to switch between keys and respond to obtain food or respond to obtain a changeover.

In other studies where the organism remains free to choose, the problem is one of transgressions (Bandura 1974). A transgression occurs when after being trained to choose a large delayed reward the organism demonstrates its preference for the small immediate reward. Experiment 5 did not aim to deal with the transgression problem but attempted to find the sources of control over the behaviour of selecting a large delayed or a small frequent reward. In other words, to find environmental variables which might control the controlling response. Experiment 5 asked whether the switching response as a free operant behaviour was open to reward and punishment contingencies. Results suggested that the solution to the transgression problem lies in the contingencies which control the controlling response.

The analogy of the smoker may be used to explain the reasons why a free operant choice of a large delayed reward over a small frequent reward is regarded as self control. A smoker has frequent opportunities to engage in smoking and presumably gains a small reinforcement each time. By exhibiting self control the large rewards, good health, long life etc. become available but their reinforcing effects are not as immediate. Using this analogy the small 2 seconds reward on a VI75 schedule was regarded as a small but frequent reinforcement while the 8 seconds food on a VI300 schedule was regarded as a large delayed reinforcement. Experiment 5 demonstrated that experimental control of the controlling response was possible, either through reward or through punishment. The effects were present when the additional direct consequences for switching were present and diminished when the consequences were removed. In phase IV of experiment 5 (Table 11) the B_2/B_1 ratios were low indicating that the extra reward and punishment had affected the pigeon's choice behaviour in the presence of the line stimuli. In phase V when the added contingencies had been removed only one of the subjects returned to the equivalent baseline ratios of phase III. It appeared that the discriminative stimuli (lines) retained some degree of control over the switching response for 13 to 16 sessions, continuing to inhibit switching out of a LD component and switching into a SF component. Furthermore in phase VI when the line stimuli were removed altogether the ratios rose to higher levels consistent with those demonstrated in phase II.

The continued control of switching by the line signals for 13-16 sessions into phase V suggests that a degree of long term control of the switching response is possible.

The literature of the experimental analysis of behaviour suggests three ways in which control may persist in the apparent absence of direct consequences. Zimmerman (1969) demonstrated that responding could be

maintained for long periods by conditioned reinforcement. In Zimmerman's studies animals continued to respond when conditioned reinforcement was available even though each response postponed food reinforcement. The question can then be raised - can switching into a LD schedule or switching out of an SF schedule be maintained by conditioned reinforcement?

Another area of research where responding persists in the apparent absence of direct consequences is the study of avoidance behaviour. The persistence of avoidance responding is well documented (Mackintosh 1974) and has been advocated as a necessary feature of self control by Premack and Anglin (1973).

A further possibility exists in Skinner's concept of the transition from contingency governed behaviour to rule governed behaviour (Skinner 1969). In this type of analysis rules can be derived from a reinforcing system, evoking behaviours when reinforcing contingencies are rare and contingency shaped behaviour therefore unlikely. Skinner related rule governed behaviour to maxims concerned with not only perseverence, providing a supplement to contingencies which are weak, but also to long deferred consequences. Both are issues of significance in the maintenance of self control.

While the present study demonstrated that switching behaviour as a choice and a commitment was able to be controlled by direct contingencies its long term maintenance, whether by conditioned reinforcement, avoidance procedures or other strategies, is an important but unresolved issue.

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APPENDIX 1. Experiment 1 (All Sessions)

Pigeon and Phase	Session	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green food key	Red food key	Sw. key during green	Sw. key during red
M5	1	609	930	146	257	38	39	18	22	20.39	26.82	29.87	34.68	7.16	9.58
Phase	2	739	944	330	401	48	48	19	21	23.76	27.61	31.10	34.19	13.89	14.52
I	3	952	584	464	301	43	44	20	20	24.67	20.42	38.59	28.60	18.81	14.74
	4	1020	766	202	196	38	39	20	20	25.62	20.67	39.81	37.06	7.88	9.48
	5	802	1133	117	136	33	33	20	20	21.19	23.82	37.85	47.57	5.52	5.71
	6	626	1192	155	219	35	35	20	20	13.02	28.76	48.08	41.45	11.9	7.61
	7	1312	1018	479	356	45	45	22	18	25.50	23.38	51.45	43.54	18.78	15.23
	8	827	993	295	415	37	38	20	20	14.13	24.85	58.53	29.96	20.88	16.70
	9	912	621	344	187	32	32	18	22	19194	14.78	45.74	42.22	.7.25	12.65
	10	725	1206	206	326	37	38	19	21	15.24	26.49	47.57	45.53	13.52	12.36
	11	1222	1263	424	194	41	41	20	20	25.22	19.66	48.45	64.24	16.81	9.87
	12	1467	1668	468	265	51	50	24	16	30.6	25.47	47.94	64.59	15.29	10.40
	13	1591	1720	235	196	39	40	22	18	25.66	23.21	62.00	74.11	9.16	8.44
	14	1187	1226	286	249	37	36	20	20	21.73	20.31	54.63	60.37	13.17	12.26
	15	1561	1300	345	208	38	38	23	17	24.28	21.84	64.3	59.53	14.21	9.53
	16	2096	2102	359	472	52	52	24	16	29.54	29.18	70.01	72.04	12.16	16.18
	17	1551	1404	282	280	36	35	20	20	21.42	21.06	72.41	66.67	13.17	13.30
	18	1321	1520	222	317	38	38	20	20	18.53	24.08	71.29	63.12	11.98	13.16
	19	1652	1039	249	220	36	35	19	21	22.03	18.53	74.99	56.08	11.31	11.88
	20	1590	1097	196	228	38	37	20	20	23.25	19.74	68.39	55.58	8.43	11.55
	21	1320	1179	157	173	33	32	20	20	22.53	19.42	58.62	60.71	6.98	8.87
Phase	1	1023	913	208	215	27	26	13	27	18.39	14.68	55.64	62.20	11.31	14.65
II	2	688	1140	217	149	26	26	10	30	13.21	18.59	52.01	61.33	16.43	8.02
Malfunc-	3	766	987	246	139	25	24	10	30	14.14	15.68	54.18	62.95	17.40	8.87
tion	4	372	817	172	106	15	15	4	21	7.65	11.62	48.63	70.31	22.49	9.13
	5	1008	1489	339	167	33	33	18	22	19.26	18.52	52.34	80.40	17.61	9.02
	6	995	1852	337	240	37	37	13	27	20.03	25.45	47.68	72.77	16.83	9.43
	7	791	1396	426	351	36	35	11	29	17.80	22.91	44.44	60.94	23.90	15.32
	8	898	1093	438	378	38	38	15	25	20.50	21.28	43.81	51.37	21.37	17.77
	9	846	1110	455	425	39	39	12	28	24.70	22.50	34.26	40.37	18.43	15.46

	10	1239	1325	399	283	42	41	14	26	23.18	22.74	53.46	58.27	17.22	12.45
	11	942	1529	306	259	34	35	14	26	20.31	22.76	46.39	67.18	15.07	11.38
	12	863	1686	501	187	40	39	12	28	22.86	22.45	37.76	75.10	21.92	8.33
	13	764	1308	635	204	38	38	11	29	23.03	21.01	33.18	62.26	27.58	9.71
	14	612	1161	565	290	37	37	13	27	20.78	20.41	29.50	56.90	27.19	14.21
	15	710	803	564	216	38	38	14	26	23.64	19.05	30.04	42.16	23.86	11.34
	16	592	1147	341	210	36	36	13	27	17.01	23.64	34.81	48.52	20.05	8.89
	17	720	1036	529	219	37	37	12	28	22.34	20.93	32.23	49.50	23.68	10.23
Phase III	1	591	1030	319	385	42	41	32	8	21.81	27.32	27.10	37.70	14.63	14.09
	2	912	1057	247	315	42	42	32	8	25.06	23.05	36.39	25.86	9.86	13.67
	3	748	1013	300	235	41	40	27	13	19.70	25.63	37.97	39.52	7.90	9.17
	4	941	1135	239	321	40	40	31	9	19.81	25.01	47.43	45.38	12.05	12.83
	5	1277	866	260	312	38	38	32	8	27.39	21.59	57.03	40.11	11.61	14.45
	6	1345	625	278	428	40	41	32	8	26.10	19196	51.52	31.31	10.65	21.44
	7	1239	536	143	523	35	36	32	8	24.88	21.51	49.80	24.92	5.75	24.31
	8	1181	556	211	412	40	40	30	10	26.19	19.58	44.92	28.40	8.03	21.04
	9	1161	710	195	294	40	41	32	8	27.32	19.92	42.50	19.92	7.14	14.76
	10	960	632	206	621	38	38	31	9	22.30	22.83	43.05	27.18	9.24	27.20
	11	1048	640	205	411	41	42	31	9	24.90	21.27	42.09	30.09	8.23	19.32
	12	1423	406	77	331	34	34	30	10	25.50	16.50	55.80	24.61	3.02	20.06
	13	1501	287	33	362	20	20	32	8	28.60	11.82	52.48	24.28	1.15	30.63
	14	1697	452	45	290	25	25	32	8	28.74	15.14	59.04	29.85	1.56	19.15
	15	1618	273	33	258	23	23	33	7	27.86	11.92	58.07	22.90	1.18	21.64
	16	1410	326	52	303	27	27	31	9	27.53	14.03	51.21	23.23	1.88	13.04
	17	1778	435	70	390	36	36	33	7	34.09	15.02	52.15	28.96	2.05	25.96
Phase IV	1	1097	508	266	393	42	41	4	36	25.60	20.87	42.85	24.34	10.39	18.83
	2	715	916	380	268	46	45	4	36	23.33	25.31	30.64	36.19	16.28	10.58
	3	441	1462	198	78	34	33	7	33	17.09	30.66	25.80	47.68	11.58	2.54
	4	372	1543	508	110	38	36	3	37	18.33	26.79	20.29	57.60	27.71	4.11
	5	322	1442	443	57	24	24	5	35	12.13	25.95	26.55	55.57	36.52	2.20
	6	348	2066	466	30	26	26	5	35	12.48	26.76	27.88	77.20	37.33	1.12
	7	307	2555	332	32	23	23	4	36	12.43	37.31	24.69	68.48	26.71	0.86
	8	544	1943	503	92	40	40	2	38	19.38	28.44	28.07	68.31	25.95	3.23
	9	379	2208	261	65	27	27	3	37	11.83	25.77	32.03	85.68	22.06	2.52
	10	526	2125	410	111	38	38	4	36	17.12	30.87	30.72	68.83	21.80	3.59
	11	449	1310	641	180	38	38	5	35	20.59	20.94	21.80	62.55	31.30	8.59
	12	365	1678	531	110	36	36	5	35	17.48	27.47	20.88	61.08	30.37	4.00

	13	756	2139	313	47	28	28	3	37	19.61	30.28	38.55	70.64	15.96	1.55
	14	238	2380	230	31	15	14	3	37	7.24	35.49	32.87	67.06	31.76	0.87
	15	386	1841	498	53	23	23	4	36	16.02	28.80	24.09	63.93	31.08	1.84
	16	289	2432	204	38	24	23	3	37	9.19	32.22	31.45	75.49	22.22	1.18
	17	428	2846	332	39	22	22	4	36	15.76	29.73	27.15	95.73	21.06	1.32
Phase V	1	476	2403	293	93	31	31	19	21	25.93	58.17	18.35	41.30	11.30	1.60
	2	484	1609	343	400	36	36	20	20	13.95	28.17	34.70	57.12	24.59	11.11
	3	767	1022	352	301	36	37	20	20	16.86	22.60	45.50	45.23	20.88	13.32
	4	1641	977	318	280	39	38	21	19	25.48	19.06	64.41	51.25	12.48	14.69
	5	1380	702	586	344	38	39	22	18	27.76	15.16	49.72	46.31	21.11	22.70
	6	935	1077	503	863	45	45	18	22	19.06	27.39	49.06	39.32	26.39	31.51
	7	900	1070	543	695	41	41	20	20	18.06	23.23	49.84	46.07	30.07	29.92
	8	858	1086	409	648	38	38	20	20	15.14	24.65	53.15	44.06	25.34	26.29
	9	730	1356	341	578	39	39	19	21	14.53	24.97	50.24	54.31	23.47	23.15
	10	1042	1285	507	527	38	39	19	21	17.27	22.61	60.34	56.84	29.36	23.31
	11	1412	1110	596	323	39	40	21	19	24.43	19.02	57.80	58.36	24.40	16.99
	12	939	1859	311	586	40	39	17	23	15.12	28.32	62.11	65.65	20.56	20.70
	13	1421	1012	716	353	39	39	21	19	25.87	16.37	54.93	61.86	27.68	21.58
	14	1016	1368	448	663	42	42	19	21	19.23	24.41	52.84	56.05	23.30	27.16
	15	1150	1023	590	307	39	39	20	20	25.35	18.36	45.37	55.72	23.27	16.73
	16	886	1036	500	581	39	39	20	20	21.07	21.47	42.05	48.26	23.73	27.07
	17	1130	946	583	405	37	37	20	20	22.24	18.25	50.81	51.84	26.21	22.19
	18	799	1295	313	424	39	39	20	20	15.13	27.88	52.81	46.45	20.69	15.21
	19	685	1209	146	246	37	37	19	21	16.44	27.91	41.66	43.32	8.88	8.82
	20	918	1108	103	175	37	37	21	19	22.39	25.72	41.00	43.08	4.60	6.80
	21	1152	857	651	378	36	37	20	20	20.91	16.23	55.09	52.81	31.14	23.29
	22	1302	1026	624	464	42	41	19	21	25.28	19.31	51.50	53.13	24.68	24.03
	23	991	1010	347	497	36	35	18	22	15.80	21.25	62.72	47.53	21.96	23.39
	24	899	1269	460	989	42	42	18	22	14.63	29.04	61.45	43.70	31.45	34.06
	25	869	992	466	945	41	40	20	20	16.23	27.16	53.54	48.89	28.71	34.79
	26	1023	940	683	623	38	38	19	21	18.94	21.01	54.02	44.74	36.06	29.65
	27	1060	1128	481	580	40	41	21	19	19.69	23.27	53.83	48.47	24.43	24.92
	28	1292	1277	591	706	48	49	21	19	22.21	22.61	58.70	56.48	26.61	31.23

M6	1	701	460	167	143	35	34	21	19	21.76	17.99	32.21	25.57	7.67	7.95
Phase	2	764	848	164	224	35	35	22	18	23.40	20.69	32.65	40.99	7.01	10.83
I	3	970	1389	109	105	36	36	20	20	19.33	26.47	50.18	52.47	5.64	7.74
	4	1759	1182	171	110	35	34	20	20	27.60	26.76	63.73	70.53	6.20	6.56
	5	959	1105	258	183	35	34	20	20	20.59	18.93	46.58	58.37	12.53	9.67
	6	956	742	225	160	33	34	21	19	23.34	14.59	40.96	50.86	9.64	10.97
	7	1168	761	439	246	41	41	22	18	27175	15.55	42.09	48.94	16.11	15.82
	8	800	807	247	283	39	39	19	21	20.81	20.36	38.44	39.64	11.87	13.90
	9	657	1232	154	285	42	41	16	24	17.13	30.25	38.35	40.73	8.99	9.42
	10	780	966	170	185	38	38	20	20	21.29	21.65	36.64	44.62	7.99	8.55
	11	1070	952	243	168	42	42	23	17	25.10	20.27	41.80	46.97	9.50	8.29
	12	1582	950	224	181	38	38	20	20	23.65	18.40	66.89	51.63	9.48	9.84
	13	1327	1361	161	205	34	35	20	20	19.74	21.65	67.23	62.87	8.16	9.47
Phase	1	1045	712	265	260	27	27	10	30	16.73	13.74	62.47	51.82	15.84	18.93
II	2	930	1259	230	308	30	31	11	29	14.26	17.88	65.22	70.42	6.13	17.23
	3	1193	915	301	237	30	30	10	30	16.76	15.53	71.19	58.92	17.96	15.26
	4	655	1301	196	226	26	26	10	28	10.87	16.59	60.26	78.42	18.04	13.63
	5	1193	1770	313	194	36	37	11	29	18.68	23.06	63.87	76.76	16.76	8.42
	6	882	1364	309	188	34	34	12	28	16.31	22.20	54.08	61.45	18.95	8.47
	7	957	1533	373	264	38	39	14	26	19.24	24.73	49.74	61.99	19.39	10.68
	8	940	1355	422	281	39	39	14	26	18.91	23.94	49.71	56.60	22.32	11.74
	9	947	1225	160	120	34	35	15	25	17.58	24.70	53.87	49.60	9.11	4.86
	10	1373	1495	305	247	40	41	14	26	20.39	24.73	66.34	60.46	14.96	9.99
	11	1199	1288	181	198	35	35	15	25	16.66	22.84	71.97	56.40	10.87	8.67
	12	1135	834	252	120	34	35	13	27	21.64	16.78	52.45	49.71	11.65	7.16
	13	1081	835	493	317	39	38	14	26	23.09	17.17	46.82	48.64	21.36	18.47
	14	782	990	262	310	33	34	13	27	16.33	21.31	47.89	46.46	16.04	14.55
	15	880	949	328	311	37	36	12	28	20.19	19.61	43.59	48.40	16.25	15.86
	16	748	1647	319	299	44	43	11	29	18.68	27.98	40.05	58.87	17.08	10.69
	17	1004	1553	546	285	43	43	13	27	23.66	22.63	42.44	68.63	23.08	12.60
	18	1002	767	431	292	38	37	13	27	20.81	18.60	48.15	41.22	20.72	15.69
	19	862	994	383	292	43	44	14	26	21.72	23.33	39.69	42.61	17.63	12.52
	20	704	1434	321	261	41	40	13	27	19.12	26.23	36.82	54.67	16.79	9.95
	21	831	963	248	283	38	37	13	27	18.12	23.44	45.86	41.08	13.69	12.07
	22	704	893	263	300	38	37	13	27	17.24	23.53	40.84	37.95	15.26	12.75
	23	601	716	408	247	38	38	12	28	23.47	19.15	25.50	37.39	17.31	12.90

	24	571	650	392	255	37	37	14	26	21.85	19.23	26.13	33.80	17.94	13.26
	25	666	717	376	210	35	35	14	26	19.45	19.17	34.24	37.40	19.33	10.95
	26	716	602	534	219	40	39	14	26	24.40	18.51	29.34	32.52	21.89	11.83
	27	547	692	367	321	39	39	12	28	19.67	24.48	27.81	28.27	18.66	13.11
	28	706	741	482	292	40	40	14	26	22.86	19.67	30.88	37.67	21.08	14.84
Phase III	1	567	814	271	282	35	35	28	12	16.29	22.07	34.81	36.88	16.64	12.78
	2	722	556	431	303	40	41	31	9	24.01	19.73	30.07	28.18	17.95	15.36
	3	817	617	409	420	45	45	32	8	23.16	24.57	35.28	25.11	17.66	17.09
	4	907	591	270	349	40	41	32	8	21.58	21.00	42.02	28.14	12.51	16.61
	5	825	483	242	333	44	43	31	9	21.35	23.51	38.4	20.54	11.33	14.16
	6	623	327	138	183	34	34	32	8	17.53	17.00	35.54	19.23	7.87	10.76
	7	785	424	214	307	42	42	32	8	22.26	21.80	35.27	19.45	9.61	14.08
	8	729	683	250	362	43	41	30	10	21.62	22.61	33.72	30.21	11.56	16.01
	9	669	340	210	418	44	41	32	8	21.10	21.50	31.70	15.81	9.95	26.43
	10	673	355	117	357	39	39	29	11	21.27	21.14	31.64	16.79	5.50	16.88
	11	966	342	70	213	29	30	33	7	27.58	14.16	35.02	24.15	2.53	15.04
	12	1051	305	53	208	24	25	32	8	27.57	13.23	38.22	23.02	1.92	15.72
	13	1124	361	42	206	27	27	30	10	26.27	13.89	42.78	25.98	1.59	14.83
	14	1042	382	57	284	32	33	32	8	27.34	14.8	38.10	25.81	2.08	11.00
	15	882	414	87	376	35	35	32	8	26.51	16.90	33.27	24.49	3.28	22.24
	16	893	437	87	338	39	38	31	9	27.03	18.23	33.03	23.97	3.21	18.54
Phase IV	1	882	656	128	330	45	44	6	34	26.95	21.97	32.72	29.85	4.74	15.02
	2	593	831	232	267	47	46	5	35	23.88	24.67	24.83	33.68	9.71	10.82
	3	596	752	263	258	45	45	3	37	20.12	22.54	28.35	33.36	12.51	11.44
	4	713	1068	429	303	44	44	4	36	21.80	21.73	32.70	49.14	19.67	13.94
	5	440	857	414	282	49	49	4	36	24.56	24.97	17.91	34.32	16.85	11.29
	6	305	841	420	195	44	44	2	38	20.61	23.78	14.79	35.36	20.37	8.20
	7	343	827	522	175	40	40	4	36	19.70	20.13	16.41	41.08	26.49	8.62
	8	239	872	328	171	34	34	5	34	15.86	19.20	15.06	45.41	26.68	8.90
	9	470	954	586	265	48	48	3	37	23.02	23.92	20.41	39.88	25.45	11.07
	10	255	1154	420	201	40	40	6	34	18.75	21.66	13.60	53.27	27.73	9.27
	11	425	901	489	156	40	30	4	36	17.66	35.32	24.06	25.50	27.68	4.41
	12	761	1148	765	65	36	36	2	38	28.24	24.00	26.94	47.83	27.08	2.71
	13	494	908	715	110	38	38	3	37	24.67	21.33	20.03	42.57	35.7	5.16
	14	274	1109	367	205	35	35	5	35	13.51	30.12	20.29	36.82	27.17	6.80
	15	213	1110	400	182	36	36	3	37	14.23	27.04	14.97	41.05	28.10	6.73

Malfunction	16	593	2181	732	213	61	61	5	35	28.24	50.65	20.99	43.06	25.92	4.20
	17	138	1072	316	90	31	31	4	36	12.14	31.85	11.36	33.66	26.02	2.82
	18	317	1044	534	79	34	33	3	37	19.59	28.68	16.69	36.41	27.25	2.76
	19	424	1021	649	49	28	28	4	36	19.10	27.05	22.19	36.61	33.97	1.81
	20	293	1084	762	80	37	37	3	37	20.18	44.95	14.52	24.12	37.76	1.78
	21	135	750	192	63	26	26	6	34	10.42	26.68	12.96	28.11	18.42	2.37
Phase V	1	409	1026	403	256	35	35	20	20	13.10	28.92	31.22	35.48	30.77	8.86
	2	675	918	554	288	40	40	20	20	19.37	23.40	34.85	39.13	28.60	12.31
	3	941	553	818	165	38	38	23	17	28.94	14.13	32.52	39.14	28.27	11.68
	4	493	441	515	196	36	35	18	22	20.47	13.18	24.09	33.46	25.16	14.88
	5	877	683	644	262	41	42	22	18	28.62	15.68	30.64	43.56	22.51	16.71
	6	792	724	425	440	37	37	20	20	17.81	20.60	38.86	35.15	23.86	21.36
	7	499	516	416	379	41	41	20	20	22.04	20.03	22.64	25.77	18.88	18.93
	8	676	702	516	451	41	41	20	20	22.72	19.29	29.76	36.40	22.71	23.38
	9	572	850	318	638	40	40	19	21	17.12	25.03	33.42	33.96	18.58	25.49
	10	573	1002	246	613	42	42	19	21	24.47	27.71	39.74	36.16	17.00	22.13
	11	792	806	449	438	41	41	20	20	22.30	21.11	31.93	38.18	20.14	20.75
	12	843	921	615	450	43	43	20	20	23.88	19.97	35.31	46.12	25.76	22.54
	13	609	858	467	528	41	41	19	21	19.57	22.29	31.12	38.50	23.87	23.69
	14	846	1259	551	825	48	49	15	25	20.85	29.85	40.58	42.18	26.42	27.64
	15	833	922	662	566	44	43	20	20	23.26	21.19	35.82	43.52	28.46	26.71
	16	863	1057	543	486	43	43	21	19	22.96	21.23	37.58	49.79	23.65	22.90
M7 Phase I	1	554	812	348	348	41	42	19	21	15.64	14.16	35.42	37.34	22.25	24.58
	2	903	1245	558	398	42	42	20	20	22.37	23.31	40.19	53.45	24.94	17.07
	3	1230	1424	332	397	41	41	20	20	19.14	23.86	64.26	59.68	17.35	16.64
	4	1970	1223	517	279	42	43	22	18	30.97	16.39	63.61	74.62	16.69	17.02
	5	1709	1016	405	371	40	40	19	21	23.34	17.81	73.22	57.05	17.35	21.39
	6	877	1757	234	393	34	35	19	21	13.29	23.73	65.99	74.04	17.61	16.56
	7	1205	1031	370	180	35	35	20	20	23.13	14.80	52.10	69.66	16.00	12.16
	8	1376	1107	348	225	41	41	23	17	27.33	17.81	50.35	62.16	13.10	12.63
	9	806	1244	155	357	38	38	17	23	15.97	27.30	50.47	45.57	9.71	13.08
	10	759	999	187	280	39	39	20	20	20.82	23.15	36.46	43.15	8.98	12.10
	11	924	1288	155	226	37	37	20	20	21.17	22.96	43.65	56.10	7.32	9.84
	12	997	951	227	185	38	37	20	20	24.27	20.22	41.08	47.04	9.36	9.15
	13	697	1009	228	274	36	37	20	20	18.03	22.24	38.66	45.36	12.65	12.32

Phase II	1	852	1292	284	258	32	33	12	28	16.19	19.35	52.63	66.77	17.55	13.34
	2	618	1006	293	169	27	28	10	30	15.33	14.95	40.32	67.29	19.12	11.31
	3	634	1356	276	177	29	30	11	29	13.56	19.37	45.94	70.01	19.92	9.14
	4	536	1280	263	144	24	23	7	23	11.31	15.09	47.40	84.83	23.26	9.55
	5	906	1970	499	242	41	41	13	27	20.80	25.34	43.56	77.75	23.99	9.55
	6	1030	1223	549	347	40	40	14	26	23.82	18.76	43.24	65.20	23.05	18.50
	7	1027	1740	354	156	36	36	15	25	20.79	22.46	49.40	77.48	17.45	6.95
	8	924	1613	424	477	39	39	13	27	21.39	24.79	43.38	65.07	19.91	19.25
	9	979	1563	449	357	42	42	13	27	21.61	23.54	45.31	66.40	20.78	15.17
	10	909	1332	436	239	36	35	12	28	20.96	19.54	43.37	68.17	20.81	12.24
	11	832	1572	440	235	37	38	14	26	20.50	24.25	40.59	64.83	21.47	9.69
	12	680	1184	376	163	32	31	13	27	18.44	18.45	36.88	64.18	20.39	8.84
	13	913	1423	409	326	40	40	12	28	20.53	23.35	44.47	60.95	19.93	13.97
	14	636	1228	370	393	33	32	12	28	15.35	20.10	41.44	61.10	24.11	19.56
	15	628	1268	325	348	32	33	12	28	14.18	19.74	42.49	64.24	21.99	17.63
	16	1044	1187	456	304	38	38	14	26	22.45	17.83	46.51	66.58	20.32	17.05
	17	876	1519	356	347	34	35	13	27	16.23	21.25	53.98	71.49	21.94	16.43
	18	983	1352	578	581	44	45	13	27	21.81	23.49	45.08	57.56	26.51	24.74
Phase III	1	831	1576	448	473	40	40	30	10	18.27	22.60	45.48	69.73	24.52	20.93
	2	1309	1166	472	401	40	40	29	11	23.29	29.77	56.20	56.45	20.70	20.28
	3	1721	1347	475	520	47	47	33	7	26.42	23.34	65.14	57.71	17.98	22.28
	4	1457	898	476	757	44	44	32	8	22.61	22.30	64.44	40.27	21.05	40.27
	5	1562	1064	372	954	46	46	34	6	22.35	24.88	69.89	42.77	16.64	38.34
	6	2114	692	295	664	44	44	31	9	27.97	20.53	75.58	33.71	10.55	32.34
	7	1498	894	176	570	34	34	30	10	19.56	17.15	76.58	52.13	9.00	32.34
	8	1507	1174	179	555	37	37	29	11	19.19	21.60	78.53	54.35	9.32	25.69
	9	1513	910	275	575	42	42	29	11	29.13	19.89	71.60	45.75	13.01	28.90
	10	1469	824	255	498	42	42	30	10	21.06	19.64	69.75	41.95	12.10	25.35
	11	1615	1100	256	451	43	43	30	10	21.21	22.30	76.14	49.32	12.06	20.22
	12	1542	902	409	695	50	50	31	9	23.53	24.48	65.53	36.84	17.38	28.39
	13	1417	824	440	606	46	45	30	10	21.21	21.91	66.80	37.60	20.74	27.65
	14	1985	926	317	717	47	46	31	9	24.52	22.55	80.95	41.06	12.92	31.79
	15	1972	695	209	495	44	44	32	8	25.59	19.07	77.06	36.44	8.16	25.95
	16	1342	651	279	588	42	42	31	9	23.08	19.55	58.17	33.29	12.09	30.07
	17	1804	702	344	709	45	46	31	9	25.14	18.97	71.75	37.00	13.68	37.37

	18	1497	750	179	655	44	45	32	8	24.64	23.17	60.75	32.36	7.26	28.26
	19	531	768	210	679	41	42	32	8	22.52	20.96	67.98	36.64	9.33	32.15
	20	1415	652	269	653	42	43	30	10	23.07	20.12	61.34	32.41	11.66	32.46
Phase IV	1	1438	1163	354	703	46	46	3	37	23.02	21.96	62.47	52.96	15.38	32.01
	2	996	1264	450	457	46	46	3	37	22.70	20.98	43.87	60.24	19.82	21.78
	3	1296	1217	454	444	44	44	4	36	22.90	21.63	56.59	56.26	19.82	20.52
	4	750	1761	663	448	46	46	3	37	21.73	21.36	34.51	82.44	30.61	20.97
	5	514	1131	437	207	40	40	4	36	18.34	19.68	28.02	57.46	23.82	10.51
	6	455	1864	401	142	44	44	4	36	18.95	24.23	24.01	76.92	21.16	5.34
	7	472	1736	532	155	42	43	4	36	20.65	28.98	22.74	59.90	25.63	5.34
	8	133	1788	630	107	34	33	5	35	15.64	28.78	8.50	62.12	40.28	3.71
	9	681	1542	666	65	34	34	4	36	18.66	23.27	36.49	66.26	35.69	2.79
	10	427	1350	668	183	42	42	4	36	20.55	21.06	20.77	64.10	32.50	8.68
	11	103	1314	613	140	36	37	6	34	18.20	20.97	5.65	62.66	33.68	6.67
	12	740	1136	594	113	34	34	4	36	19.87	17.80	37.24	63.82	29.89	6.34
	13	588	2444	371	143	39	39	4	36	14.71	33.98	39.97	71.92	25.22	4.20
	14	523	1252	475	68	29	29	5	35	17.56	22.76	29.79	55.01	27.05	2.99
	15	592	185	720	148	38	39	2	38	21.95	25.56	26.97	72.42	32.80	5.79
	16	694	1550	729	172	38	38	5	35	22.62	23.19	30.68	66.84	32.23	7.42
Phase V	1	1052	957	691	357	38	37	20	20	23.14	15.76	45.47	60.73	29.86	22.66
	2	723	1687	429	670	39	39	20	20	15.61	25.15	46.35	67.08	27.50	26.64
	3	1608	1166	675	476	40	40	21	18	24.50	15.81	65.64	70.59	27.55	30.11
	4	559	942	191	272	38	38	20	20	16.34	32.67	34.21	28.84	11.69	8.33
	5	696	1092	277	268	39	39	21	19	18.01	24.48	38.65	44.61	15.38	10.95
	6	1749	721	879	244	42	42	20	20	32.32	9.45	54.12	76.30	27.20	25.61
	7	1344	861	541	389	41	41	21	19	26.56	18.02	50.61	47.78	20.36	21.59
	8	1098	1081	514	469	42	41	20	20	25.23	18.41	43.51	58.72	20.38	25.48
	9	551	1268	311	698	37	37	18	22	14.17	24.20	38.89	52.40	21.95	28.85
	10	768	1112	503	552	39	39	20	20	18.78	21.76	40.90	51.11	26.79	25.37
	11	605	1025	270	510	30	30	27	13	12.57	18.56	48.13	55.23	21.48	27.48
	12	1012	1168	533	525	40	40	20	20	21.66	21.06	46.73	55.46	24.61	24.93
	13	1248	834	745	405	41	41	21	19	26.17	17.31	47.69	48.18	28.46	23.40
	14	862	928	433	572	37	37	20	20	17.38	21.92	49.60	42.34	24.97	26.10
	15	1564	878	688	343	42	42	21	19	28.70	15.11	54.50	58.11	23.98	22.70
	16	1394	926	654	345	42	43	21	19	27.56	16.87	50.38	54.89	23.73	20.45
	17	683	1146	292	703	38	38	19	21	15.57	25.80	43.81	44.42	18.76	27.25

	18	712	1020	316	585	39	40	20	20	15.99	23.252	44.53	43.37	19.76	24.88
	19	724	1327	350	613	40	40	19	21	16.44	25.76	44.04	51.52	21.29	23.80
	20	932	1074	486	654	41	42	20	20	20.34	21.77	45.83	49.34	23.90	30.05
	21	954	938	526	565	39	38	20	20	19.97	19.63	47.78	47.79	26.33	28.79
	22	792	1099	413	705	36	36	20	20	18.08	20.73	43.81	53.01	22.84	34.01
M8	1	1612	1062	108	49	18	18	22	18	28.89	20.64	55.80	51.45	3.74	2.37
Phase	2	1366	1264	109	120	25	26	20	20	19.13	22.09	71.41	57.22	5.70	5.43
I	3	1161	1568	271	286	39	40	22	18	19.40	26.47	58.34	59.24	13.62	10.80
	4	1052	1261	189	195	35	36	19	21	17.98	23.00	58.51	54.83	10.51	8.58
	5	1588	1577	207	271	45	45	22	18	25.58	28.45	62.08	55.43	8.10	9.53
	6	1070	1047	66	47	17	16	19	21	16.99	19.39	62.99	54.00	3.89	2.43
	7	1344	1236	270	196	37	36	19	21	20.39	21.87	65.92	56.52	13.25	8.97
	8	1180	1426	176	171	33	34	19	21	17.39	24.17	67.86	59.00	10.12	7.08
	9	1167	1333	301	263	38	39	21	19	21.33	24.71	54.72	53.95	14.12	10.65
	10	1090	1201	178	197	35	36	20	20	19.22	23.86	56.72	50.34	8.94	8.26
	11	974	871	151	117	34	35	20	20	19.78	23.38	49.25	37.26	7.64	5.01
	12	914	894	124	159	30	30	19	21	17.51	21.33	52.20	41.92	7.09	7.46
	13	987	1250	136	175	36	35	19	21	20.38	25.14	48.43	49.73	6.68	6.97
	14	1009	967	131	145	31	30	20	20	22.45	19.18	44.95	50.42	5.84	7.56
	15	984	1150	112	113	33	32	18	22	20.93	22.53	52.25	51.04	5.36	5.02
	16	988	1111	150	180	32	33	19	21	18.91	21.61	52.25	51.42	7.93	8.33
	17	817	1023	147	202	33	33	19	21	20.72	21.76	39.34	47.02	7.08	9.29
Phase	1	1065	1097	118	296	30	29	13	27	17.08	18.89	62.36	58.08	6.91	15.67
II	2	892	1198	138	226	29	28	11	29	14.58	18.04	61.18	66.41	9.47	12.53
	3	643	933	82	143	25	25	11	29	14.70	19.66	43.75	47.46	5.58	7.28
	4	682	986	83	141	27	28	12	28	17.35	22.33	39.30	44.15	4.78	6.31
	5	817	1557	168	112	36	35	10	30	20.03	26.36	40.79	59.07	8.39	4.25
	6	721	1437	262	63	30	30	11	29	19.64	24.39	36.71	58.92	13.34	2.59
	7	875	1958	342	124	35	35	14	26	18.08	25.29	48.40	77.43	19.90	4.91
	8	537	1340	186	104	32	32	13	27	16.21	26.72	33.13	50.15	11.48	3.90
	9	519	1151	134	27	21	21	14	26	15159	27.45	33.29	41.93	8.60	0.99
	10	582	1359	107	33	20	20	13	27	13.46	27.79	43.24	48.91	2.48	1.19
	11	700	1403	114	54	25	25	12	28	15.91	25.61	44.00	54.79	7.17	2.11
	12	744	1418	174	50	30	30	13	27	19.73	26.24	37.71	54.04	8.82	1.91
	13	769	1279	226	98	32	32	12	28	19.04	23.35	40.39	44.40	11.87	4.20

	14	755	887	232	104	36	36	14	26	20.92	25.42	54.78	55.36	11.09	4.10
	15	911	1335	283	146	38	37	13	27	20.25	25.67	37.92	37.07	13.98	5.69
	16	800	1329	247	138	33	34	15	25	18.02	24.01	34.90	54.64	13.71	5.75
	17	709	1297	258	125	34	34	14	26	19.13	23.74	44.99	35.15	13.49	5.27
	18	664	1008	297	95	32	31	13	27	18.89	20.56	52.01	49.03	15.73	4.62
Phase III	1	781	1499	299	150	42	42	34	6	23.53	27.63	33.19	54.25	12.71	5.43
	2	881	1221	201	193	37	37	32	8	20.45	26.34	43.08	46.36	9.83	7.33
	3	963	879	163	164	34	35	31	9	21.20	23.17	45.42	37.94	7.64	7.08
	4	1014	542	97	146	30	30	30	10	20.77	19.48	48.82	27.82	4.67	7.50
	5	1149	324	90	197	31	30	30	10	25.91	17.52	44.35	18.49	3.47	11.24
	6	1079	457	105	247	35	37	32	8	24.56	21.13	42.02	21.63	4.28	11.69
	7	1334	434	145	309	40	40	31	9	25.68	20.87	51.95	20.80	5.65	14.81
	8	1038	186	98	272	29	29	31	9	23.39	17.81	44.38	10.41	4.19	15.27
	9	1113	233	155	569	37	37	32	8	23.40	22.61	47.56	10.27	6.62	25.08
	10	896	199	152	657	35	35	30	10	20.72	20.05	43.24	9.93	7.34	32.77
	11	1675	395	111	481	38	37	31	9	28.28	18.71	59.23	21.11	3.93	25.71
	12	1608	607	75	227	33	32	30	10	25.21	15.90	63.78	38.18	2.98	14.28
	13	1303	668	83	249	31	30	30	10	21.30	19.52	61.17	34.22	3.89	12.75
	14	1448	438	69	261	36	36	30	10	24.44	18.56	59.24	23.59	2.82	14.06
	15	1156	371	94	249	37	37	32	8	24.67	18.48	46.85	20.07	3.81	13.47
	16	1244	419	104	374	37	37	31	9	23.32	18.58	53.34	22.55	4.45	20.12
	17	1171	231	89	308	34	34	29	11	23.50	17.15	49.82	13.46	3.78	17.95
Phase IV	1	1236	679	261	392	47	47	5	35	24.66	25.16	50.12	26.98	10.58	15.58
	2	847	726	242	129	42	42	3	37	24.23	22.72	34.95	31.95	9.98	5.67
	3	782	2649	284	70	48	48	6	34	27.09	45.29	28.86	58.48	10.48	1.54
	4	282	1813	164	25	20	20	4	36	10.37	28.79	27.19	50.50	15.81	0.87
	5	250	2194	167	40	20	20	3	37	10.45	34.68	23.92	63.26	15.98	1.16
	6	230	2257	257	31	20	20	5	35	11.54	30.97	19.93	72.87	22.27	1.00
	7	224	2322	274	22	20	20	3	37	11.04	31.09	20.28	74.68	24.81	0.70
	8	165	2367	171	22	20	20	4	36	8.71	31.34	18.94	75.52	19.63	0.70
	9	253	1716	406	25	20	20	4	36	12.43	32.62	20.35	52.60	32.66	0.76
	10	114	1701	253	27	16	16	2	38	7.62	29.65	14.86	57.36	32.98	0.91
	11	135	1714	130	22	14	14	2	38	5.62	33.12	24.02	51.75	23.13	0.66
	12	345	1646	345	40	28	28	4	36	15.80	29.04	21.83	56.68	21.83	1.37
	13	301	1502	232	23	28	27	3	37	14.06	27.99	21.40	53.66	22.97	0.82

Phase V	1	350	1023	287	74	28	28	16	24	15.38	22.87	22.75	52.60	18.66	3.23
	2	242	1239	240	49	22	22	17	23	11.54	22.79	20.97	54.36	20.79	2.15
	3	450	1099	279	380	36	35	19	21	15.23	27.42	29.54	40.08	18.31	13.85
	4	461	1183	145	182	31	30	19	21	12.95	26.67	35.60	44.36	11.20	6.83
	5	860	734	484	152	42	41	21	19	27.34	16.86	31.45	43.54	17.71	9.02
	6	964	681	408	151	35	35	21	19	27.58	16.59	34.96	41.05	14.80	9.11
	7	1131	1054	370	89	34	34	24	16	25.28	16.46	44.73	64.04	14.63	5.40
	8	464	1073	174	178	30	30	19	21	13.50	24.91	34.37	43.08	12.89	7.15
	9	1275	1262	310	460	40	40	20	20	18.41	26.26	69.26	48.06	16.83	17.52
	10	586	1083	146	325	34	34	20	20	14.42	27.31	40.64	39.66	10.13	11.90
	11	532	711	308	541	41	41	21	19	20.48	24.43	25.97	29.11	15.03	22.15
	12	830	685	438	276	38	38	20	20	23.94	17.31	34.67	39.58	18.29	15.95
	13	635	704	260	317	35	35	20	20	19.64	20.61	32.34	34.16	13.24	15.38
	14	517	1001	183	307	35	36	18	22	15.83	25.27	32.66	39.62	11.56	12.15
	15	907	762	410	271	40	40	20	20	24.43	20.38	37.13	37.39	16.79	13.30
	16	757	946	307	234	35	34	20	20	17.76	20.22	42.62	46.79	17.28	11.58
	17	732	710	310	255	37	37	19	21	22.62	19.43	32.36	36.55	13.71	13.13
	18	668	1229	357	368	40	41	20	20	19.35	24.76	34.53	49.64	18.45	14.87
	19	933	815	695	486	44	44	21	19	28.10	20.42	33.19	39.92	24.73	23.80
	20	933	515	578	385	41	40	21	19	27.86	18.40	33.49	28.39	20.75	21.23
	21	624	849	306	363	36	37	20	20	18.81	22.54	33.18	37.67	16.27	16.11
	22	487	1091	246	431	36	35	19	21	14.78	24.80	32.95	44.00	16.65	17.38

APPENDIX 2. Experiment 2 (Data from the Last Six Sessions of Each Phase).

Pigeon and Phase	Session	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green food key	Red food key	Sw. key during green	Sw. key during red
M6	11	1012	904	668	576	8	9	13	17	24.08	20.01	42.02	45.17	27.74	28.78
Phase	12	1057	900	596	525	9	9	16	14	21.99	19.97	48.06	45.06	27.10	26.28
I	13	842	1170	638	874	7	6	14	16	17.99	27.97	46.80	41.83	35.46	31.24
	14	811	1082	474	751	9	8	14	16	16.98	24.99	47.76	43.29	27.91	30.05
	15	817	752	606	548	8	8	15	15	20.97	18.98	38.96	39.62	28.89	28.87
	16	1121	678	726	432	9	8	16	14	26.96	16.00	41.58	42.37	26.92	27.00
Phase	12	437	893	358	159	7	7	4	26	15.88	23.60	27.52	37.84	22.54	6.74
II	13	409	1012	460	173	8	7	3	27	16.19	26.37	25.26	38.38	28.41	6.56
	14	651	600	1037	120	9	9	5	25	33.94	20.01	19.18	29.99	30.55	6.00
	15	702	1479	728	417	12	12	5	25	25.65	44.14	27.37	33.51	28.38	9.45
	16	210	777	230	195	5	6	2	28	10.16	27.11	20.67	28.66	22.64	7.19
	17	457	651	465	148	7	8	3	27	16.13	18.88	28.33	34.48	28.83	7.84
Phase	11	302	1169	475	83	9	9	3	27	12.47	22.02	24.22	53.09	38.09	3.77
III	12	221	1015	687	40	9	8	2	28	17.15	22.94	12.89	44.25	40.06	1.74
	13	191	1075	486	19	8	8	3	27	13.78	23.99	13.86	44.81	35.27	0.79
	14	71	1225	241	16	6	6	2	28	10.09	29.73	7.04	41.20	23.89	0.54
	15	15	1108	24	1	1	1	1	29	0.94	26.03	15.96	42.40	25.53	0.04
	16	231	948	646	83	11	10	4	26	15.49	21.71	14.91	43.66	41.70	3.82
Phase	11	258	685	385	157	16	16	4	26	11.86	20.77	21.75	32.98	32.46	7.56
IV	12	273	562	621	69	16	16	3	27	17.41	20.33	15.68	27.64	35.67	3.39
	13	578	479	989	110	20	20	5	25	25.38	14.42	22.77	33.27	38.97	7.63
	14	234	632	663	131	17	17	4	26	15.55	20.65	15.04	30.60	42.64	6.34
	15	292	576	599	114	16	17	4	26	17.55	17.74	16.63	32.46	34.13	6.43
	16	249	858	421	147	15	17	3	27	11.65	24.77	21.37	34.63	36.14	5.93

Phase V	11	92	998	14	17	13	13	2	28	3.00	28.37	30.67	35.18	24.67	0.60
	12	102	715	43	16	15	15	2	28	4.00	27.34	25.50	26.15	10.75	0.58
	13	148	820	90	14	14	14	3	27	4.84	24.39	30.57	33.62	18.59	0.51
	14	133	912	70	20	14	14	2	28	4.37	24.81	30.43	36.75	16.01	0.80
	15	97	1078	38	14	11	11	2	28	2.64	28.27	36.74	38.13	14.39	0.49
	16	165	891	126	24	19	20	2	28	6.88	23.95	23.98	37.20	18.31	1.00
Phase VI	25	496	618	133	272	52	52	20	10	14.19	17.64	34.95	35.03	9.37	15.41
	26	535	593	202	191	57	59	19	11	19.12	16.05	27.98	36.94	10.56	11.90
	27	431	643	210	338	52	53	19	11	15.52	19.59	27.77	32.82	13.53	17.25
	28	392	560	134	250	48	50	20	10	13.19	15.95	29.72	35.11	10.15	15.67
	29	506	475	205	189	52	54	21	9	18.44	13.21	27.44	35.95	11.11	14.30
	30	519	466	189	213	48	52	20	10	17.69	13.23	29.33	35.22	10.68	16.09
Phase VII	9	439	688	206	535	17	18	18	12	14.81	23.01	29.64	29.90	13.90	23.25
	10	714	425	347	343	18	18	16	13	23.10	15.61	30.90	27.22	15.02	21.97
	11	592	426	371	316	15	16	20	10	20.69	13.33	28.61	31.95	17.93	23.70
	12	702	392	377	310	18	19	22	8	23.45	14.40	29.93	27.22	16.07	21.52
	13	511	343	256	246	16	14	20	10	18.97	11.98	26.93	28.63	13.49	20.53
	14	486	390	206	280	15	14	19	11	17.72	14.17	27.42	27.52	11.62	19.76
Phase VIII	12	672	398	205	291	7	8	21	9	20.42	14.27	29.97	27.89	10.03	20.39
	13	316	513	185	480	12	13	18	12	19.37	26.92	16.31	19.05	9.55	17.83
	14	310	616	147	640	10	11	15	15	13.66	30.50	22.69	20.19	10.67	20.98
	15	304	547	247	845	11	12	16	14	15.78	32.94	19.26	16.60	15.65	25.65
	16	393	481	209	539	14	14	16	14	17.76	24.96	22.12	19.27	11.76	21.59
	17	356	397	227	507	9	11	19	11	19.11	23.31	18.62	17.03	11.87	25.18
Phase IX	10	963	335	243	450	7	8	23	7	28.10	16.07	34.27	20.85	8.65	28.00
	11	526	640	230	641	5	6	18	12	20.04	22.98	26.25	27.85	11.48	27.89
	12	421	743	108	494	6	6	18	12	15.33	30.13	27.46	24.66	7.05	16.40
	13	886	333	274	388	6	7	23	7	26.38	12.48	33.59	26.68	10.39	31.09
	14	609	412	260	448	5	6	19	11	22.67	14.86	26.86	27.73	11.47	30.15
	15	366	294	148	296	4	5	20	10	17.60	16.26	20.80	18.08	8.41	18.20

Phase X	10	1113	922	691	1166	8	9	15	15	26.12	30.46	42.61	30.27	26.45	38.28
	11	933	254	723	429	6	6	14	16	23.83	10.73	39.15	26.47	30.34	39.98
	12	512	889	341	1073	6	7	12	18	12.64	27.87	40.51	31.90	26.98	38.50
	13	595	744	422	974	8	8	14	16	18.50	26.67	32.16	27.90	22.81	36.52
	14	595	794	5.8	1029	8	9	12	18	17.67	25.32	33.67	31.28	29.32	40.64
	15	491	739	438	887	8	9	12	18	16.27	27.22	30.18	27.15	26.92	32.59
M7	9	892	993	391	522	59	59	15	15	13.67	16.33	65.25	60.81	28.60	31.97
Phase I	10	761	758	304	329	59	59	14	16	14.50	14.54	52.48	52.13	20.97	22.63
	11	763	817	373	511	63	63	15	15	13.88	16.83	54.97	48.53	26.87	30.36
	12	922	806	423	459	71	71	15	15	18.43	17.30	50.03	46.59	22.95	26.53
	13	1049	914	500	510	72	72	15	15	19.00	17.86	55.21	51.18	26.32	28.56
	14	764	790	361	366	60	61	15	15	17.14	15.63	44.57	50.54	21.06	23.42
Phase II	8	162	1819	371	77	37	37	2	28	8.23	22.43	19.68	81.10	45.08	3.43
	9	159	1815	337	74	37	37	4	26	8.41	21.30	18.91	85.21	40.07	3.47
	10	169	1526	348	120	44	45	4	26	8.94	21.40	18.90	71.30	38.92	5.60
	11	154	1716	429	53	38	38	3	27	9.83	19.72	15.67	87.02	43.64	2.69
	12	206	1428	482	62	41	40	3	27	11.87	18.41	17.35	82.02	40.81	3.56
	13	103	1935	421	46	30	30	2	28	8.12	23.34	12.68	82.90	51.85	1.97
Phase III	13	213	665	665	288	15	16	3	27	13.06	18.29	16.31	62.11	50.92	15.75
	14	210	1587	565	314	16	16	3	27	11.81	22.08	17178	71.18	47.84	14.22
	15	188	1671	582	255	17	17	4	26	13.73	21.77	13.69	76.75	42.38	11.71
	16	295	1262	720	122	20	19	4	26	22.63	18.52	13.03	68.14	31.81	6.58
	17	515	1134	1139	182	21	21	5	25	27.90	15.44	18.46	73.45	40.82	9.63
	18	226	1262	582	163	20	19	4	26	19.36	18.89	11.67	66.81	30.06	8.62
Phase IV	10	337	1573	760	232	11	11	4	26	19.88	22.55	16.86	69.75	38.04	10.29
	11	349	1082	635	209	11	11	4	26	20.83	16.47	16.75	65.70	30.48	12.69
	12	195	1500	296	227	8	8	4	26	10.67	21.91	18.27	68.46	27.74	10.36
	13	483	1314	575	205	9	9	4	26	18.94	18.69	23.50	70.30	30.36	10.97
	14	314	1195	564	217	11	11	4	26	18.16	20.43	17.29	58.49	31.06	10.62
	15	288	1366	496	161	11	10	3	27	16.24	18.36	16.63	74.36	30.54	8.76

Phase V	14	272	1794	422	360	6	7	4	26	14.39	26.39	18.90	67.98	29.37	13.64
	15	173	1158	349	303	4	5	4	26	10.82	20.81	15.98	55.64	32.25	14.56
	16	233	1435	354	418	5	5	3	27	11.19	24.14	20.82	59.44	31.63	17.31
	17	464	1411	586	267	7	7	7	23	20.17	20.37	23.00	69.26	29.05	13.10
	18	355	1439	418	318	6	6	5	25	14.22	21.74	24.96	66.19	29.39	14.62
	19	636	1260	894	309	8	9	5	25	27.60	19.92	23.04	63.25	32.39	15.51
Phase VI	9	1060	984	438	541	7	7	21	9	20.57	21.74	51.53	45.26	21.29	24.88
	10	937	887	414	730	8	8	21	9	20.02	30.29	46.80	29.28	20.68	24.10
	11	914	894	506	718	9	9	20	10	20.93	30.53	43.67	29.28	24.17	23.51
	12	739	1253	400	820	7	8	18	12	17.31	36.70	42.69	34.14	23.10	22.34
	13	1061	955	700	599	6	6	23	7	25.06	21.96	42.34	43.49	27.93	27.27
	14	723	896	451	499	7	8	22	8	18.73	20.63	38.60	43.43	24.07	24.18
Phase VII	10	773	634	429	539	10	11	23	7	20.36	20.25	37.95	31.30	21.07	26.61
	11	946	664	495	587	11	11	24	6	19.54	20.11	48.41	33.01	25.33	29.18
	12	1463	143	772	92	10	10	27	3	28.66	3.56	51.04	40.16	26.93	25.84
	13	1120	327	503	181	8	8	23	7	21.38	7.51	52.38	43.54	23.52	24.10
	14	891	274	476	217	9	9	23	7	23.62	10.74	37.72	25.51	20.15	20.20
	15	1147	379	502	260	8	9	24	6	24.08	11.19	47.63	33.86	20.84	24.03
Phase VIII	8	670	746	191	635	18	19	22	8	12.66	25.57	52.92	29.17	15.07	24.83
	9	959	792	337	599	18	18	21	9	15.12	18.28	63.42	43.32	22.28	32.76
	10	1269	510	449	410	17	19	24	6	22.95	14.66	70.77	34.78	19.56	27.96
	11	956	342	403	377	16	17	23	7	20.76	12.15	46.05	28.14	19.41	31.02
	12	890	531	326	539	17	18	22	8	17.86	18.29	49.83	29.03	18.25	29.46
	13	797	804	236	663	18	19	21	9	15.61	22.58	51.06	35.61	15.12	29.36
Phase IX	8	752	544	202	465	49	41	20	10	14.49	13.82	51.89	39.36	13.94	33.64
	9	1004	685	270	536	56	57	25	5	15.98	14.89	62.83	46.00	16.90	36.00
	10	725	414	217	373	48	49	22	8	15.74	11.89	46.06	34.82	13.79	31.37
	11	1051	424	221	386	47	48	25	5	17.76	10.91	59.17	38.86	12.44	35.38
	12	986	427	187	420	47	48	24	6	17.39	12.22	56.69	34.94	10.75	34.36
	13	1065	387	278	435	42	42	23	7	20.14	12.28	52.87	31.51	13.80	35.42

Phase	9	908	596	464	416	58	58	15	15	17.51	12.90	51.86	46.20	26.50	32.25
X	10	721	914	391	677	62	63	14	16	15.02	19.07	48.00	47.93	26.03	35.50
	11	689	877	395	559	67	67	14	16	14.51	18.17	47.48	48.27	27.22	30.76
	12	570	499	411	461	65	65	15	15	13.13	13.28	43.41	37.58	31.30	34.71
	13	671	622	412	492	57	57	15	15	15.26	14.46	43.97	43.02	27.00	34.02
	14	903	645	470	412	62	63	17	13	18.06	13.74	50.00	46.94	26.62	29.99

APPENDIX 3. Experiment 3. (Data from the last six sessions of each phase.)

Pigeon and Phase	Session	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green food key	Red food key	Sw. key during green	Sw. key during red
M5	9	323	584	291	676	27	28	11	19	10.08	20.24	32.04	28.82	28.86	33.39
Phase	10	532	987	353	456	34	34	20	20	15.66	21.65	33.97	45.88	22.54	21.06
I	11	478	716	247	538	29	30	12	18	9.46	20.42	50.52	35.06	26.10	26.34
	12	535	693	369	491	34	33	13	17	16.15	17.95	33.13	38.61	22.84	27.35
	13	412	739	304	518	33	33	13	17	13.38	21.30	30.79	34.69	22.72	24.31
	14	476	446	397	278	30	31	17	13	18182	14.18	25.29	31.45	21.09	19.61
Phase	9	951	946	129	160	17	17	17	13	34.69	12.80	27.41	73.90	3.71	12.50
II	10	1060	853	55	67	8	8	15	15	15.46	13.66	68.56	62.45	3.56	4.90
	11	1004	940	76	38	6	5	16	14	13.82	10.95	72.64	85.84	5.49	3.47
	12	1063	1177	0	0	0	0	16	14	14.12	13.52	74.28	82.62	0.00	0.00
	13	1039	1212	3	2	1	1	15	15	12.99	13.68	79.98	88.59	0.23	0.14
	14	1052	0230	0	0	0	0	15	15	16.04	16.71	65.58	73.60	0.00	0.00
Phase	12	305	2105	572	2	28	1	0	30	14.92	21.79	20.44	96.60	38.34	0.09
III	13	25	1997	766	1	30	1	0	30	19.90	26.77	1.26	74.60	38.49	0.03
	14	70	1878	720	5	31	4	0	30	15.07	29.39	4.64	63.90	47.77	0.17
	15	61	2679	900	0	28	0	0	30	18.93	30.73	3.22	87.17	47.54	0.00
	16	39	2318	563	0	27	0	0	30	15.33	25.68	2.54	90.26	36.72	0.00
	17	25	2388	757	0	28	0	0	30	16.00	24.72	1.56	96.60	47.31	0.00
Phase	9	183	1906	242	0	19	0	5	25	9.69	21.68	18.88	87.91	26.00	0.00
IV	10	151	1688	139	3	18	2	6	24	10.67	21.67	14.15	77.89	13.02	0.13
	11	322	2079	227	0	16	0	6	24	12.16	23.33	26.48	89.11	18.66	0.00
	12	272	2015	211	0	18	0	5	25	9.58	21.44	28.39	93.93	22.02	0.00
	13	379	1845	343	0	23	0	3	27	14.77	26.32	25.66	70.09	23.22	0.00
	14	330	1948	148	0	21	0	4	26	12.27	24.53	26.89	79.41	12.06	0.00
Phase	10	615	1423	30	0	10	0	9	21	17.83	15.64	34.49	90.98	1.68	0.00
V	11	778	1724	25	0	10	0	10	20	20.03	18.43	38.84	93.54	1.24	0.00
	12	821	1575	22	0	10	0	10	20	19.83	16.81	41.40	03.60	1.10	0.00

	13	1026	2049	29	0	9	0	9	21	14.91	16.27	68.81	125.93	1.94	0.00
	14	1006	1576	20	0	10	0	10	20	19.19	13.89	52.42	113.46	1.04	0.00
	15	1263	2083	21	0	10	0	10	20	19.82	18.37	63.72	113.39	1.05	0.00
Phase VI	11	877	2172	9	9	4	9	18	12	15.45	23.79	56.76	91.29	0.58	0.37
	12	1161	1762	0	5	0	3	16	14	18.41	20.91	63.06	84.26	0.00	0.23
	13	1321	1938	3	28	1	8	21	9	18.92	26.39	69.82	73.41	0.16	1.06
	14	1286	2260	4	16	2	15	22	8	16.22	30.25	79.28	74.71	0.25	0.53
	15	957	1641	2	12	2	12	20	10	15.97	24.40	59.92	67.25	0.12	0.49
	16	1055	1695	1	6	1	6	17	13	15.75	22.06	66.98	76.84	0.06	0.27
Phase VII	12	2178	450	0	123	0	24	27	3	24.75	15.63	88.00	28.79	0.00	7.86
	13	2439	445	0	314	0	28	29	1	27.62	28.12	88.30	24.55	0.00	17.32
	14	1431	1102	1	274	1	21	25	5	19.75	25.10	72.45	43.90	0.05	10.91
	15	1761	656	1	266	0	25	25	5	20.30	22.11	76.57	32.97	0.00	12.03
	16	1872	656	1	176	1	20	27	3	24.05	16.23	77.83	40.41	0.04	10.84
	17	2015	493	0	238	0	27	26	4	23.23	17.41	86.74	28.31	0.00	13.67
Phase VIII	9	2572	235	2	565	1	31	30	0	29.58	17.46	86.94	13.45	0.06	32.35
	10	2520	181	1	497	1	30	30	0	28.30	18.71	89.05	10.22	0.04	26.56
	11	2060	201	1	524	1	30	30	0	24.17	20.36	85.19	9.87	0.04	25.74
	12	2729	168	1	575	1	30	30	0	26.13	19.36	104.44	8.68	0.04	29.70
	13	1967	269	0	320	0	29	30	0	26.50	15.71	74.23	17.12	0.00	20.37
	14	2433	154	2	561	2	33	30	0	29.72	16.24	81.86	9.48	0.00	34.54
Phase IX	13	1466	529	2	54	2	12	19	11	17.06	12.48	85.93	42.39	0.12	4.33
	14	1584	480	3	45	3	14	20	10	18.25	10.85	86.79	44.65	0.16	4.19
	15	1545	305	2	53	2	10	18	12	20.34	6.29	75.96	48.49	0.10	8.43
	16	1571	398	0	42	0	12	21	9	15.77	9.43	99.62	42.21	0.00	4.45
	17	2298	472	16	60	11	14	20	10	28.55	8.38	80.49	56.32	0.56	7.16
	18	1637	451	3	50	3	10	18	12	19.97	10.01	81.97	45.05	0.15	5.00
Phase X	8	886	565	473	243	29	29	17	13	18.10	12.02	48.78	47.00	26.13	20.27
	9	442	889	178	331	28	28	14	16	9.11	19.12	46.32	46.40	19.54	17.31
	10	936	783	257	194	29	30	15	15	18.71	15.05	50.03	25.03	13.74	12.89
	11	854	750	425	359	26	27	16	14	16.72	12.65	51.08	59.28	25.42	28.37
	12	600	510	432	227	24	24	16	14	14.59	10.48	41.12	48.66	29.60	21.66
	13	668	627	441	355	28	28	14	16	15.27	13.84	43.74	45.30	28.88	24.20

M8	10	711	699	524	387	24	30	17	13	15.58	12.57	45.63	55.60	33.63	30.78
Phase	11	466	612	308	269	25	27	13	17	14.74	15.28	31.61	40.05	20.89	17.60
I	12	362	600	167	221	22	23	14	16	10.27	16.13	35.24	37.19	16.26	13.70
	13	443	648	276	152	26	26	17	13	15.88	12.62	27.89	43.42	17.38	12.04
	14	637	609	251	174	27	28	15	15	18.08	13.19	35.25	44.49	13.89	12.71
	15	626	697	214	176	27	28	16	14	16.46	15.43	38.03	45.17	13.00	11.41
Phase	16	906	374	1	18	1	14	20	10	20.63	10.74	43.91	34.82	0.04	1.67
II	17	1175	463	9	25	4	13	20	10	23.67	12.64	49.64	36.62	0.38	1.97
	18	928	621	7	28	4	10	18	12	18.75	11.49	49.49	54.05	0.37	2.44
	19	926	693	1	12	1	4	16	14	16.06	12.76	57.66	54.31	0.06	0.94
	20	599	796	0	0	0	0	15	15	14.23	14.00	42.09	56.85	0.00	0.00
	21	834	1183	0	0	0	0	15	15	14.00	16.40	59.57	72.13	0.00	0.00
Phase	15	147	1884	219	1	27	1	0	30	17.91	19.11	8.20	96.49	12.22	0.05
III	16	109	2681	238	1	28	1	0	30	16.42	27.67	6.63	96.89	14.49	0.03
	17	64	2493	130	1	28	1	0	30	22.93	27.71	2.79	89.96	5.66	0.03
	18	70	2763	199	0	27	0	0	30	21.09	27.58	3.31	100.18	9.43	0.00
	19	84	2775	190	0	28	0	0	30	15.83	29.73	5.30	93.34	12.00	0.00
	20	313	2915	229	0	28	0	0	30	21.31	28.99	14.68	100.55	10.74	0.00
Phase	9	438	1745	132	0	20	0	4	26	14.99	24.14	29.21	72.28	8.80	0.00
IV	10	470	1790	102	0	17	0	6	24	14.11	23.51	83.30	76.13	7.22	0.00
	11	321	1480	54	0	9	0	10	20	11.24	18.64	28.55	79.39	4.80	0.00
	12	408	1629	52	0	13	0	8	22	8.47	17.85	48.17	91.26	6.13	0.00
	13	503	1698	98	0	17	0	6	24	13.91	21.00	36.16	80.85	7.04	0.00
	14	821	1794	146	0	23	0	4	26	20.98	23.97	39.13	74.84	6.95	0.00
Phase	11	476	1124	24	0	12	0	8	22	12.70	13.72	37.48	81.92	1.89	0.00
V	12	803	1468	59	0	17	0	6	24	18.33	20.54	43.81	71.47	3.22	0.00
	13	591	1603	39	0	12	0	8	22	14.23	18.92	41.53	84.73	2.74	0.00
	14	935	1382	16	0	8	0	10	20	19.01	18.24	49.18	75.77	0.84	0.00
	15	504	1680	87	1	18	1	6	24	19.77	22.92	25.49	73.30	4.40	0.04
	16	558	1379	37	0	12	0	8	22	14.99	18.88	37.22	73.04	2.46	0.00

Phase VI	14	1215	423	2	33	0	12	21	9	15.98	14.13	75.97	29.94	0.13	2.34
	15	1128	560	0	58	0	11	18	12	18.10	14.10	62.32	39.72	0.00	4.12
	16	1705	529	17	65	1	9	24	6	21.25	12.91	80.24	40.98	0.80	5.04
	17	1355	503	0	63	0	13	22	8	19.36	19.12	69.99	26.31	0.00	3.30
	18	1030	1025	2	72	1	17	20	10	14.11	20.98	73.00	48.86	0.15	3.44
	19	1298	683	1	87	0	12	22	8	16.00	18.45	81.93	37.02	0.07	4.72
Phase VII	13	1939	807	7	158	5	23	25	5	23.56	14.66	82.30	55.09	0.29	10.77
	14	1326	1232	0	41	0	12	22	8	16.22	19.62	81.75	62.79	0.00	2.08
	15	1386	1099	1	83	1	19	24	6	17.82	20.65	77.77	43.22	0.05	4.01
	16	1482	557	0	100	0	24	27	3	23.58	14.47	62.84	38.49	0.00	6.91
	17	1624	371	4	77	2	19	24	6	25.26	17.08	64.29	21.72	0.15	4.50
	18	1417	1083	1	97	1	21	22	8	17.50	19.02	80.97	56.94	0.05	5.09
Phase VIII	10	2000	155	1	175	1	30	30	0	29.25	18.91	68.38	8.20	0.03	9.25
	11	1847	133	0	375	0	29	30	0	26.30	25.41	70.23	5.23	0.00	14.76
	12	1256	247	0	169	0	30	30	0	30.01	28.04	71.84	8.81	0.00	6.03
	13	1999	159	0	189	0	29	30	0	26.63	23.99	75.07	6.63	0.00	7.88
	14	1807	146	0	232	0	29	30	0	25.60	20.45	70.59	7.14	0.00	11.34
	15	1643	119	0	207	0	29	30	0	22.68	20.37	72.44	5.84	0.00	10.16
Phase IX	8	1169	827	6	0	0	3	17	13	16.02	12.79	72.97	64.66	0.00	0.47
	9	1020	930	0	5	0	2	16	14	17.13	16.34	59.54	56.91	0.00	0.30
	10	1230	485	0	19	0	6	18	12	19.61	14.10	62.72	34.39	0.00	1.34
	11	926	855	0	0	0	0	15	15	13.70	11.96	67.59	71.48	0.00	0.00
	12	1119	755	1	4	1	3	15	14	16.39	10.36	68.27	72.88	0.06	0.39
	13	1059	1590	11	6	9	3	12	18	16.20	16.19	65.37	98.21	0.68	0.37
Phase X	8	602	948	97	94	22	23	14	16	13.63	16.21	44.17	58.48	7.12	5.80
	9	792	863	141	105	24	24	16	14	17.62	16.99	44.95	50.79	8.00	6.18
	10	643	788	149	167	24	25	14	16	13.67	14.61	47.04	53.94	10.90	11.43
	11	642	913	149	135	26	27	15	15	15.63	18.19	41.07	53.11	9.53	7.85
	12	703	886	161	162	24	25	14	16	14.31	18.05	45.92	51.96	10.51	9.50
	13	529	704	147	118	22	23	16	14	13.33	13.49	39.68	52.19	11.02	8.74

APPENDIX 4. Experiment 4 (data from the last six sessions of each phase)

Pigeon and Phase	Session	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green food key	Red food key	Sw. key during green	Sw. key during red
M9	15	576	938	184	303	27	28	13	17	12.84	16.83	44.86	55.73	14.35	18.00
Phase	16	649	910	178	234	27	29	15	15	13.53	16.01	47.97	56.84	13.15	14.61
I	17	549	877	120	287	27	27	14	16	11.26	18.31	48.76	47.90	10.65	15.67
	18	658	851	180	229	26	27	15	15	14.62	15.78	45.01	53.93	12.31	14.51
	19	662	785	143	156	23	24	17	13	13.72	13.20	48.25	59.46	10.42	11.81
	20	470	910	132	381	26	28	12	18	10.04	19.52	46.81	46.61	13.14	19.51
Phase	18	429	445	309	336	29	28	14	16	13.95	15.78	30.75	28.20	22.15	21.29
II	19	532	641	350	303	28	30	16	14	15.66	15.90	33.97	40.31	22.34	19.05
	20	752	713	327	296	28	30	15	15	17.17	15.13	43.79	47.12	19.04	19.56
	21	636	961	211	257	27	28	13	17	12.94	16.22	49.14	59.24	16.30	15.84
	22	494	811	330	258	29	28	14	16	15.42	14.41	32.03	56.28	21.40	17.90
	23	637	866	333	383	28	31	14	16	31.35	16.53	47.71	52.38	24.94	23.16
Phase	8	342	748	166	399	29	28	16	14	11.84	19.55	28.88	38.26	14.02	20.40
III	9	675	985	241	542	31	29	14	16	11.34	18.60	59.52	52.95	21.25	29.13
	10	750	737	368	476	27	28	14	16	14.38	15.33	52.16	48.08	25.59	31.05
	11	858	630	386	409	30	28	16	14	15.67	13.79	54.75	45.69	24.63	29.65
	12	949	909	388	729	36	34	13	17	16.02	19.98	59.23	45.49	24.21	36.48
	13	726	731	328	674	31	30	14	16	13.54	17.79	53.61	41.09	24.22	37.88
Phase	8	849	621	624	601	32	30	17	13	16.71	15.97	50.80	38.88	37.34	37.63
IV	9	414	792	264	571	26	25	14	16	8.52	17.51	48.70	45.23	30.99	33.18
	10	675	582	528	641	31	31	15	15	14.09	16.14	47.90	36.05	37.47	39.71
	11	695	623	514	605	31	30	16	14	14.41	18.84	48.23	33.06	35.60	32.11
	12	822	594	664	535	33	31	14	16	18.03	14.63	45.59	40.60	36.82	36.56
	13	557	865	375	623	32	31	12	18	11.40	17.66	48.85	48.98	32.89	35.27

M10	23	844	1048	152	183	24	25	16	14	13.47	18.09	62.65	57.93	11.28	10.11
Phase	24	743	838	131	218	25	26	18	12	13.30	16.15	55.86	51.88	9.84	13.49
I	25	648	550	171	141	23	25	14	16	13.59	12.92	47.68	42.56	12.58	10.91
	26	976	753	265	169	31	30	14	16	18.67	16.12	52.27	46.71	14.19	10.42
	27	488	853	90	269	25	24	13	17	8.54	17.09	57.14	49.91	10.53	15.74
	28	928	660	175	176	24	25	15	15	13.84	12.56	67.05	52.54	12.64	14.01
Phase	23	392	1290	188	83	24	25	15	15	14.93	21.13	26.25	61.05	12.59	3.92
II	24	276	1048	100	99	19	19	12	17	9.74	21.05	28.33	49.78	10.26	4.70
	25	365	1512	291	302	28	30	13	17	12.44	18.22	29.34	82.99	29.34	16.57
	26	498	1231	345	240	28	28	12	18	14.89	16.21	33.45	75.94	23.16	14.80
	27	431	1321	376	196	24	26	17	13	13.54	16.21	31.83	81.49	27.76	12.09
	28	372	1182	289	129	20	21	14	16	12.39	13.71	30.02	84.02	23.32	9.40
Phase	16	887	654	133	293	28	26	15	15	15.08	15.05	58.81	45.53	8.81	19.46
III	17	1035	452	169	95	26	25	16	14	21.84	10.05	47.39	44.97	3.56	9.45
	18	777	574	143	227	26	25	14	16	14.89	13.81	52.18	41.56	9.60	16.43
	19	881	546	180	235	26	24	15	15	17.25	13.72	51.07	39.79	10.43	17.12
	20	863	818	148	412	28	28	13	17	15.42	18.98	55.96	43.09	9.59	21.70
	21	608	737	101	414	26	26	17	13	10.97	16.89	55.42	43.63	9.20	24.51
Phase	8	672	728	257	291	25	27	14	15	14.25	14.30	54.84	50.90	20.97	20.34
IV	9	881	633	356	237	28	27	15	15	16.45	12.48	53.55	54.72	21.64	18.99
	10	857	731	299	338	25	25	14	16	14.01	14.41	57.09	47.13	19.92	21.79
	11	639	862	308	427	26	26	14	16	12.71	18.98	50.28	45.42	24.23	22.50
	12	970	941	333	328	27	27	15	15	16.88	19.52	57.46	48.21	19.73	16.80
	13	864	792	407	318	27	27	15	15	14.53	14.14	59.46	56.01	28.01	22.49

M11	17	459	520	115	119	26	27	16	14	15.37	14.87	29.86	34.96	7.48	8.00
Phase	18	420	763	135	252	32	31	12	18	12.46	22.06	33.70	34.58	10.83	11.42
I	19	468	558	113	139	26	26	13	17	14.79	15.53	31.64	35.93	7.64	8.95
	20	459	553	78	100	19	18	15	15	14.99	15.40	30.62	35.90	5.20	6.49
	21	423	522	80	105	21	22	14	16	10.95	16.52	38.63	31.59	7.30	6.35
	22	443	415	125	122	22	24	14	16	14.20	15.58	31.19	26.63	8.80	7.83
Phase	21	614	479	379	107	23	25	16	14	16.70	11.35	36.76	42.20	22.69	9.42
II	22	504	540	197	116	23	25	17	13	13.91	15.49	36.23	34.86	14.16	7.48
	23	449	470	268	148	24	26	16	14	13.76	16.34	32.63	28.76	19.46	9.95
	24	521	515	330	103	27	28	13	17	16.84	16.04	30.93	32.10	19.59	6.42
	25	449	576	166	69	22	23	15	15	13.97	16.24	32.14	35.46	11.88	4.24
	26	447	728	141	118	29	30	16	14	12.68	20.73	35.25	34.92	11.11	5.69
Phase	15	591	407	156	161	25	24	17	13	17.16	12.21	34.44	33.33	9.09	13.18
III	16	526	472	111	200	23	22	17	13	14.37	14.76	36.67	31.97	7.72	13.55
	17	451	657	121	321	27	27	13	17	10.50	20.70	42.95	31.73	11.52	15.50
	18	462	653	119	320	25	26	15	15	10.62	19.70	45.38	33.14	11.20	16.24
	19	605	459	252	218	26	24	16	14	17.40	12.48	34.77	36.77	14.48	17.46
	20	591	634	183	331	28	28	14	16	14.40	18.15	41.04	34.93	12.70	18.23
Phase	8	434	521	191	195	22	21	14	16	19.30	15.21	28.53	26.99	9.89	12.82
IV	9	570	652	335	330	30	30	15	15	18.60	21.32	26.73	35.05	18.01	15.47
	10	382	375	185	201	23	23	14	16	17.49	15.30	24.96	21.44	10.57	13.13
	11	497	456	191	220	24	24	16	14	12.84	16.76	29.65	35.51	14.87	13.12
	12	309	364	126	154	22	22	15	15	14.12	14.56	21.22	25.77	8.92	10.57
	13	485	375	183	265	28	27	13	17	13.37	18.93	25.62	28.04	13.68	13.99

APPENDIX 5. Experiment 5 (Data from the last six sessions of each phase)

Pigeon and Phase	Session Green	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		Green	Red	Green	Red	Green	Red	Green	Red	Green	Red	Green food key	Red food key	Sw. key during green	Sw. key during red
M2	14	1034	576	58	382	28	28	25	5	16.15	19.37	64.02	29.73	3.59	19.72
Phase	15	944	468	54	347	33	34	24	6	15.09	17.15	62.55	27.28	3.57	20.23
I	16	929	424	66	306	24	25	26	4	19.98	14.47	46.49	29.30	3.30	21.14
	17	1101	482	73	298	26	26	21	9	17.27	13.20	63.75	36.51	4.22	22.57
	18	1242	415	95	263	27	27	25	5	20.61	13.43	60.26	30.90	4.60	19.58
	19	1116	595	69	346	28	29	24	6	15.80	16.04	70.63	37.09	4.36	21.57
Phase	13	935	513	143	276	22	23	22	8	15.22	13.92	61.43	36.85	8.22	24.55
II	14	1098	403	172	318	26	27	21	9	20.90	12.95	52.53	31.11	8.22	24.55
	15	873	462	136	284	22	23	24	6	18.01	12.45	48.47	37.10	7.55	27.81
	16	1028	443	116	208	26	27	25	5	21.12	12.26	48.67	36.13	5.49	16.96
	17	813	608	149	284	25	26	24	6	18.55	13.72	43.82	44.31	8.03	20.69
	18	917	711	177	362	27	28	23	7	21.38	18.48	42.89	38.47	8.27	19.58
Phase	8	1060	649	170	362	29	29	24	6	15.18	16.07	69.83	40.10	11.20	22.39
III	9	783	628	169	454	32	32	24	6	13.48	18.83	57.66	33.30	12.45	24.11
	10	822	412	148	408	31	31	25	5	13.59	17.56	60.49	23.47	10.89	23.23
	11	716	609	178	566	32	32	24	6	12.53	19.62	57.15	31.04	14.21	28.85
	12	1054	516	248	456	33	32	24	6	18.73	15.69	56.28	32.89	13.24	29.06
	13	783	676	131	417	30	31	24	6	13.58	18.34	57.66	38.86	9.65	22.90
Phase	8	614	346	589	318	31	30	24	6	18.16	12.19	33.81	28.38	32.43	26.08
IV	9	577	560	602	363	33	35	22	8	19.24	16.99	29.99	36.03	31.34	22.70
	10	694	422	276	218	28	26	23	7	17.33	13.62	40.05	30.99	14.92	16.00
	11	758	543	206	202	31	31	23	7	20.42	12.77	37.12	42.53	10.09	16.32
	12	611	364	273	329	36	35	23	7	21.32	14.74	28.66	24.70	12.80	22.32
	13	495	366	307	375	32	31	23	7	16.53	14.56	29.95	25.14	18.57	25.76

Phase V	11	532	591	227	637	33	33	23	7	12.50	21.02	42.56	28.12	18.16	30.30
	12	665	236	379	248	26	28	23	7	18.50	10.04	35.95	23.51	20.49	24.70
	13	704	346	340	419	30	32	23	7	18.06	14.17	38.99	24.42	18.83	29.57
	14	702	299	262	443	26	28	24	6	15.31	13.72	45.86	21.80	17.11	32.29
	15	565	588	249	735	33	35	23	7	14.51	22.30	38.94	26.37	17.16	32.96
	16	586	314	319	373	29	31	25	5	17.18	13.54	34.11	23.19	18.57	27.55
Phase VI	10	644	328	147	269	23	23	23	7	16.51	11.63	39.01	28.20	8.90	23.13
	11	881	344	122	264	26	28	24	6	17.52	12.69	60.29	27.11	6.96	20.80
	12	640	456	130	479	25	26	22	8	12.52	18.51	51.53	24.69	10.47	25.88
	13	725	424	77	447	30	30	22	8	12.47	20.38	58.14	20.80	6.17	21.93
	14	722	486	108	420	28	28	22	8	12.18	18.49	59.28	26.28	8.87	22.71
	15	981	447	145	309	29	29	23	7	18.03	14.26	54.41	31.35	8.04	21.67
M6 Phase I	12	698	200	84	187	22	22	22	8	20.69	8.35	33.73	23.95	4.05	22.39
	13	409	295	66	287	23	24	23	7	18.21	12.59	22.46	23.43	3.62	22.79
	14	461	282	69	275	23	24	21	9	18.25	12.60	25.26	22.38	3.78	21.82
	15	707	187	62	213	19	20	24	6	22.48	8.73	31.45	21.42	2.75	24.39
	16	695	197	85	185	21	22	25	5	20.13	8.96	34.52	21.98	4.22	20.64
	17	460	171	125	294	23	25	24	6	18.36	11.00	25.05	15.54	6.80	26.72
Phase II	14	721	620	114	325	33	35	24	6	21.47	18.26	33.58	33.95	5.30	17.79
	16	586	551	82	346	25	25	24	6	15.72	14.46	37.27	38.10	5.21	23.92
	17	696	329	188	289	27	28	22	8	22.08	10.86	31.53	20.29	8.51	26.61
	18	523	441	122	382	28	28	25	5	17.11	15.38	30.56	28.67	7.13	24.83
	19	309	189	80	366	23	24	22	8	14.72	16.71	20.99	11.31	5.43	21.90
	20	605	412	169	347	29	30	24	6	18.19	11.97	33.26	34.41	9.29	28.98
Phase III	8	370	212	388	508	32	32	23	7	16.90	15.03	21.90	14.11	22.96	33.80
	9	475	360	337	639	32	33	24	6	15.30	16.95	31.05	21.24	22.03	37.70
	10	355	313	338	568	33	33	24	6	15.91	17.02	22.32	18.39	21.24	33.37
	11	416	341	314	485	33	33	23	7	16-04	17.27	25.94	19.75	19.58	20.08
	12	398	299	473	531	32	33	24	6	16.07	13.77	24.77	21.72	29.43	38.56
	13	403	485	306	846	33	34	24	6	13.04	21.64	30.91	22.42	23.47	39.09

Phase IV	10	535	348	261	718	34	34	25	5	14.69	19.26	36.42	18.07	17.77	37.28
	11	559	435	355	843	35	36	21	9	15.02	22.29	37.27	19.52	23.63	37.81
	12	346	257	262	292	31	30	22	8	18.45	17.78	18.75	14.46	14.20	16.42
	13	475	304	433	393	34	34	23	7	18.88	16.84	25.16	18.06	22.93	23.34
	14	522	354	465	451	33	35	23	7	20.83	15.27	25.06	23.19	22.32	29.54
	15	566	478	407	582	34	35	22	8	18.54	16.14	30.53	29.62	21.95	36.05
Phase V	8	613	613	155	507	33	33	25	5	15.67	20.33	39.12	30.16	9.89	24.94
	9	534	498	256	414	30	29	25	5	14.13	15.59	37.80	31.95	18.12	26.56
	10	675	391	341	229	31	31	25	5	21.18	10.92	31.87	35.81	16.10	20.97
	11	489	536	179	594	33	35	24	6	14.21	24.88	34.42	21.55	12.60	23.87
	12	568	272	243	206	24	26	23	7	18.11	9.60	31.37	28.34	13.42	21.46
	13	622	387	358	232	27	28	25	5	20.17	10.12	30.84	28.36	17.75	22.92
Phase VI	13	546	303	129	440	29	30	26	4	18.23	18.45	29.95	16.42	7.08	23.85
	14	668	354	160	308	25	26	26	4	18.94	12.83	35.27	27.59	8.45	24.01
	15	602	346	130	368	29	28	25	5	14.83	14.08	40.59	24.59	8.77	26.15
	16	549	301	122	399	27	28	25	5	15.67	16.47	35.04	18.28	7.79	24.23
	17	557	306	129	434	30	30	24	6	17.10	16.86	32.57	18.15	7.54	25.74
	18	541	275	142	319	24	25	23	7	15.57	12.38	34.75	22.21	9.12	25.77
M9	18	1082	398	150	753	33	32	23	7	15.17	22.42	71.32	17.75	9.68	33.58
Phase I	19	866	519	250	669	24	24	26	4	14.55	15.18	59.51	34.18	17.80	44.07
	20	884	572	117	598	24	25	22	8	13.23	15.42	66.81	37.09	8.84	38.78
	21	898	561	155	530	26	27	23	7	13.87	13.78	63.30	40.71	11.17	38.46
	22	795	413	197	471	23	24	23	7	14.84	14.04	53.57	29.41	13.27	33.54
	23	1051	551	154	480	24	25	23	7	16.83	13.92	62.45	39.58	9.15	34.48
Phase II	8	849	585	370	583	28	29	23	7	15.16	14.66	56.00	39.90	24.40	39.76
	9	880	768	328	694	29	30	23	7	14.11	16.72	62.36	45.93	23.24	41.50
	10	1268	495	346	225	29	29	25	5	22.45	9.18	56.48	53.92	15.41	24.50
	11	1202	948	322	654	28	29	25	5	17.33	17.39	69.35	54.51	18.58	37.60
	12	886	695	349	471	28	30	23	7	16.54	13.84	53.56	50.21	21.10	34.03
	13	1037	493	369	385	28	30	24	6	17.30	12.02	59.94	41.01	21.32	32.02

Phase III	8	982	456	390	405	28	28	24	6	17.50	11.16	56.11	40.86	22.29	36.29
	9	1277	724	386	662	35	35	24	6	18.44	15.92	69.26	45.48	20.93	41.58
	10	1188	670	357	446	32	32	24	6	17.40	13.11	68.28	51.11	20.52	34.02
	11	1376	550	406	419	31	31	24	6	18.95	11.55	72.62	47.62	21.42	36.28
	12	1352	506	544	446	30	30	24	6	19.74	11.31	68.49	44.74	27.56	39.43
	13	1242	658	429	452	29	31	24	6	17.34	12.68	71.63	51.90	24.74	35.65
Phase IV	31	302	539	861	1129	38	39	21	9	15.04	22.83	20.08	23.61	57.25	49.45
	32	396	469	1245	757	38	37	23	7	19.22	14.73	20.61	31.84	64.78	51.39
	33	596	456	894	580	34	33	23	7	18.52	13.63	32.36	33.46	48.53	42.55
	34	420	562	1402	629	40	41	19	11	21.01	24.65	19.99	22.80	66.73	25.52
	35	411	706	1228	841	42	41	22	8	17.66	23.41	23.28	30.16	69.54	39.52
	36	457	508	962	466	34	34	19	11	16.95	14.60	26.97	34.59	56.76	31.72
Phase V	9	795	563	587	531	31	31	23	7	16.90	14.20	47.05	39.65	34.73	33.33
	10	730	742	470	689	32	32	24	6	13.27	17.63	55.02	42.09	35.42	39.08
	11	1094	698	522	814	33	34	25	5	13.23	17.37	82.69	30.06	39.46	46.86
	12	801	897	358	902	35	36	22	8	13.83	23.22	57.92	38.63	25.89	38.85
	13	803	784	531	745	31	31	24	6	15.09	19.61	53.22	39.90	35.19	37.99
	14	871	538	507	372	26	28	23	7	16.62	11.24	52.41	47.87	30.51	33.10
Phase VI	14	1195	385	247	643	29	30	24	6	15.90	13.87	75.16	22.76	15.53	46.36
	15	1116	380	343	707	28	29	26	4	17.33	14.71	64.40	25.83	19.79	48.06
	16	1372	450	340	626	31	31	25	5	20.72	15.09	66.22	29.82	16.41	41.48
	17	1221	278	401	453	26	27	26	4	18.30	8.64	66.72	32.18	21.91	52.43
	18	999	411	201	508	28	28	24	6	16.84	14.59	59.32	28.17	11.94	34.82
	19	1011	534	220	482	29	29	24	6	15.68	15.63	64.48	34.17	14.03	30.84
M10 Phase I	14	1234	535	117	433	29	31	23	7	16.48	18.18	74.87	29.42	7.09	23.81
	15	1319	389	107	365	23	24	25	5	17.76	12.22	74.26	31.83	6.02	29.86
	16	1336	546	97	353	29	30	24	6	18.85	17.32	70.87	31.52	5.14	20.38
	17	1172	360	80	260	24	24	23	7	17.51	12.59	66.93	28.59	4.56	20.65
	18	1257	438	95	321	26	26	24	6	20.43	13.96	61.52	31.37	4.65	22.99
	19	1050	342	125	358	22	23	24	6	15.98	13.37	65.70	26.77	7.82	26.77

Phase II	10	1034	707	106	170	25	25	22	8	16.31	13.34	63.39	52.99	6.49	12.74
	11	1413	614	99	157	26	27	25	5	20.58	14.71	69/79	41.74	4.81	10.67
	12	1040	708	126	205	25	26	24	6	16.88	16.18	61.61	43.75	7.46	12.66
	13	1490	603	176	267	27	28	23	7	22.17	14.77	67.20	40.82	7.93	18.07
	14	1011	515	90	137	23	24	24	6	16.06	12.36	62.95	41.66	5.60	11.08
	15	1201	572	122	190	25	25	26	4	18.19	15.55	66.02	36.78	6.70	12.21
Phase III	10	907	763	162	206	28	30	25	5	16.77	17.51	54.08	43.58	9.66	11.76
	11	653	829	149	234	28	29	24	6	15.28	17.08	42.74	48.54	9.75	13.70
	12	1226	518	169	127	27	27	23	7	19.36	11.34	63.33	45.68	8.73	11.20
	13	999	674	288	200	29	31	24	6	19.22	13.70	51.98	49.20	14.98	14.60
	14	769	655	196	228	29	31	24	6	16.82	15.78	45.72	41.51	11.65	14.45
	15	822	554	384	224	27	29	24	6	20.06	11.48	40.98	48.26	19.14	19.51
Phase IV	28	534	412	504	188	33	32	23	7	22.85	11.88	23.37	34.68	22.06	15.88
	29	316	499	221	316	30	28	20	10	11.30	18.11	27.97	27.56	19.56	17.45
	30	603	653	646	340	37	38	22	8	25.38	14.64	23.76	44.61	23.76	23.32
	31	360	613	377	609	38	37	21	9	15.78	21.37	22.82	26.69	23.89	28.50
	32	422	651	339	435	38	37	22	8	16.81	21.10	25.11	30.86	20.17	20.62
	33	343	425	623	232	30	29	20	10	19.15	10.80	17.92	19.36	32.53	21.48
Phase V	8	870	898	449	499	35	35	25	5	15.59	17.91	55.81	50.14	28.80	27.86
	9	988	599	486	241	29	29	23	7	18.83	11.02	52.47	54.36	25.81	21.87
	10	690	796	359	473	26	28	22	8	12.99	15.19	53.12	52.41	27.64	31.14
	11	964	523	606	348	29	30	25	5	19.34	13.13	49.85	39.84	31.33	26.50
	12	867	847	540	378	31	32	24	6	17.35	14.56	49.98	58.18	31.12	25.96
	13	807	600	573	308	28	29	24	6	18.12	11.37	44.54	52.77	31.62	27.09
Phase VI	23	1251	573	127	173	27	28	24	6	21.99	14.96	56.88	38.30	5.77	11.56
	24	1042	817	151	246	27	28	25	5	15.36	16.63	67.83	49.12	9.83	14.79
	25	1191	984	204	271	30	30	24	6	17.97	17.59	66.77	55.94	11.35	15.40
	26	1208	798	244	294	30	31	26	4	19.16	16.58	63.05	48.13	12.73	17.73
	27	969	525	231	401	28	28	24	6	18.46	11.71	52.50	44.84	12.51	17.16
	28	1012	571	219	311	27	28	25	5	16.19	12.47	62.50	45.78	13.52	24.93

APPENDIX 5A. Experiment 5. Data from the last six sessions of phases III-V during the green food key colour with added signals. V = vertical signal, H = horizontal signal.

Pigeon and Phase	Session	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		V	H	V	H	V	H	V	H	V	H	Food key V	Food key H	Sw. key V	Sw. key H
M2 Phase III	8	452	608	68	102	16	13	9	15	6.67	8.51	67.77	71.45	10.19	11.99
	9	425	358	94	74	17	15	10	14	7.23	6.35	58.78	56.38	13.14	11.65
	10	402	420	69	79	15	16	11	14	6.92	6.70	58.10	62.69	9.97	11.79
	11	363	353	93	85	18	14	14	10	6.54	5.99	55.51	58.94	14.22	14.19
	12	471	583	111	137	12	21	14	10	8.91	9.82	52.87	59.37	12.46	13.95
	13	426	357	73	58	14	16	13	11	7.65	5.93	55.69	60.21	9.54	9.78
Phase IV	8	418	196	299	290	15	16	16	8	10.20	7.96	40.98	24.62	29.31	36.43
	9	368	209	337	265	15	18	12	10	11.24	7.97	32.74	26.23	29.98	33.25
	10	373	321	124	152	14	14	14	9	8.49	8.43	43.94	38.08	14.60	18.03
	11	432	326	104	102	16	15	12	11	10.89	9.53	39.67	34.21	9.55	10.70
	12	391	220	170	103	15	11	14	9	13.21	8.21	29.60	26.80	12.97	12.55
	13	334	161	203	104	17	15	16	8	11.11	5.42	30.07	29.71	18.27	19.19
Phase V	11	254	278	115	112	13	20	12	11	6.20	6.30	49.97	44.13	18.55	17.78
	12	340	325	213	166	9	17	12	11	9.60	8.90	36.52	36.52	22.19	18.65
	13	298	406	167	173	16	14	10	13	8.27	9.79	36.04	41.47	20.19	17.67
	14	333	669	158	104	12	14	10	14	8.16	7.15	40.81	93.57	19.36	14.55
	15	252	313	139	110	16	17	12	11	8.34	7.17	34.34	43.66	18.94	15.34
	16	248	338	164	155	19	10	13	12	8.24	8.94	30.10	37.81	19.90	17.34
M6 Phase III	8	201	169	233	155	14	18	13	10	9.68	7.22	20.77	23.41	24.07	21.47
	9	191	284	141	196	14	18	14	10	6.68	8.62	28.60	32.95	21.11	22.74
	10	190	165	178	160	17	16	15	9	8.58	7.33	22.14	22.51	20.75	21.83
	11	176	240	124	190	17	16	13	10	6.77	9.27	26.00	25.89	18.32	20.50
	12	174	224	186	287	15	17	15	9	6.90	9.17	25.22	24.43	26.96	31.30
	13	212	191	164	142	19	15	13	11	6.68	6.36	31.74	30.03	24.55	22.33

Phase IV	10	372	163	152	109	19	15	14	11	9.43	5.26	39.45	30.99	16.12	20.72
	11	461	98	274	81	19	16	14	7	11.61	3.41	39.71	28.74	23.60	23.75
	12	197	149	126	136	16	15	12	10	9.33	9.12	21.11	16.34	13.50	14.91
	13	273	202	189	244	16	18	11	12	8.29	10.09	31.06	20.02	21.50	24.18
	14	330	192	261	204	19	14	13	10	11.85	8.98	27.85	21.38	22.03	22.72
	15	354	212	189	218	18	16	10	11	9.85	8.69	35.94	24.40	19.18	25.00
Phase V	8	376	237	95	60	15	18	15	10	10.03	5.64	37.49	42.02	9.47	10.64
	9	219	315	97	159	14	16	12	13	5.88	8.25	37.24	38.18	16.50	19.27
	10	318	357	181	160	15	16	10	15	10.40	10.89	30.58	33.12	17.40	14.84
	11	278	211	94	85	16	17	12	12	7.71	6.50	36.06	32.46	12.19	13.08
	12	260	308	112	131	15	10	9	14	8.10	10.01	32.10	30.77	13.83	13.09
	13	325	337	180	178	13	14	12	13	10.66	9.51	30.49	35.44	16.89	18.72
M9 Phase III	8	271	185	193	212	16	12	4	2	5.15	6.01	52.62	30.78	37.48	35.27
	9	369	355	307	355	18	17	2	4	6.87	9.05	53.71	39.23	44.69	39.23
	10	385	285	233	213	15	17	2	4	6.83	6.28	56.37	45.38	34.11	33.92
	11	293	257	223	196	18	13	4	2	6.23	5.32	48.03	48.31	35.79	36.84
	12	220	286	247	199	17	13	3	3	5.66	5.65	38.87	50.62	43.64	35.22
	13	313	345	235	217	16	14	4	2	5.76	6.92	54.34	49.86	40.80	31.36
Phase IV	31	186	116	560	301	18	20	12	9	9.53	5.51	19.52	21.05	58.76	54.63
	32	192	490	755	490	18	20	13	10	10.88	8.34	17.65	58.75	69.39	58.75
	33	320	276	593	301	13	21	12	11	10.22	8.20	31.31	33.66	58.02	36.71
	34	201	219	798	604	19	21	11	8	11.83	9.18	16.99	23.86	67.46	65.80
	35	245	166	765	353	23	19	13	9	11.04	6.62	22.19	25.08	79.26	53.32
	36	179	278	498	464	16	18	9	10	7.54	9.41	23.74	29.54	66.05	49.31
Phase V	9	378	417	281	306	16	15	10	13	7.72	9.18	48.96	45.42	36.40	33.33
	10	415	315	270	200	14	18	16	8	7.43	5.84	55.85	53.94	36.34	34.25
	11	613	481	323	199	13	20	12	13	8.21	5.02	74.67	95.82	39.34	39.64
	12	417	384	167	191	16	19	10	12	6.94	6.89	60.09	55.73	24.06	27.72
	13	473	330	339	192	14	17	14	10	8.99	6.00	52.61	55.00	37.71	31.48
	14	422	449	271	236	13	13	10	13	8.21	8.41	51.40	43.39	33.01	28.06

M10	10	488	419	92	70	16	12	15	10	8.80	7.97	55.45	52.47	10.45	8.78
Phase	11	310	343	78	71	14	13	12	12	7.78	7.50	39.85	45.73	9.12	10.40
III	12	682	544	67	102	19	8	12	11	8.80	10.56	77.50	51.52	7.61	9.65
	13	606	393	141	147	14	15	12	12	10.33	8.89	58.66	39.98	13.65	16.54
	14	360	409	77	119	15	14	14	10	6.99	9.83	51.51	41.61	11.02	12.11
	15	398	424	164	220	13	14	11	13	9.31	10.25	42.75	39.44	17.62	20.47
Phase	28	290	244	296	208	16	17	13	10	12.71	10.14	22.82	24.06	23.29	20.51
IV	29	253	63	147	74	16	14	12	8	7.92	3.38	31.94	18.64	18.56	21.89
	30	342	261	342	304	18	19	12	11	13.41	11.97	25.50	21.80	25.50	25.40
	31	283	77	202	175	18	20	14	7	10.31	5.47	27.45	13.82	19.59	31.99
	32	320	102	196	143	23	15	14	8	11.24	5.57	28.47	18.31	17.44	25.67
	33	157	186	190	433	16	14	8	12	8.11	11.09	19.36	16.77	23.43	39.22
Phase	8	442	428	229	220	17	18	13	12	7.07	8.52	62.52	50.23	32.39	25.82
V	9	546	442	231	255	14	15	13	12	9.12	9.71	59.87	45.52	25.33	26.26
	10	439	251	215	144	11	15	10	12	7.81	5.18	56.21	27.40	27.53	27.80
	11	720	244	334	272	14	15	14	11	10.18	9.16	70.73	26.64	32.81	29.69
	12	456	411	314	226	15	16	13	11	9.29	8.06	49.09	50.99	33.80	28.04
	13	453	354	329	244	15	13	12	12	9.28	8.84	48.81	40.05	35.45	27.60

APPENDIX 5B. Experiment 5. Data from Phases III-V during the red food key colour with added signals. V = vertical signal; H = horizontal signal.

Pigeon and Phase	Session	Food key responses		Sw. key responses		Changeovers from		Reinforcements in		Time in		Response Rate			
		V	H	V	H	V	H	V	H	V	H	Food key V	Food key H	Sw. key V	Sw. key H
M2	8	344	305	207	155	17	12	3	3	9.42	6.85	36.52	45.19	21.97	22.96
Phase	9	262	365	214	240	13	19	4	2	9.65	9.18	27.15	39.76	22.18	26.14
III	10	178	234	189	219	15	16	3	2	9.06	8.50	19.65	27.53	20.86	25.76
	11	293	316	241	325	18	14	3	3	10.17	9.45	28.81	33.44	23.70	34.39
	12	226	290	192	264	13	19	4	2	8.08	7.61	27.97	38.11	23.76	34.69
	13	302	374	188	229	15	16	2	4	8.34	10.06	36.22	37.18	23.54	22.90
Phase	8	226	120	279	39	20	10	3	3	9.88	2.31	22.87	51.94	28.23	16.88
IV	9	331	229	312	51	22	13	5	3	12.66	3.33	26.15	68.77	24.64	15.32
	10	246	174	166	52	17	9	4	3	8.71	4.91	28.24	35.85	19.05	10.59
	11	298	245	167	35	19	12	4	3	9.56	3.26	31.17	75.15	17.46	9.96
	12	229	135	283	46	27	8	4	3	11.44	3.30	20.02	40.91	24.74	13.94
	13	239	127	325	50	24	7	4	3	11.93	2.63	20.03	48.29	27.24	19.01
Phase	11	281	310	317	319	16	17	5	2	10.59	10.43	26.54	29.73	30.03	30.58
V	12	105	131	122	126	14	14	2	5	4.28	5.76	24.54	22.75	28.50	21.88
	13	174	172	240	179	18	14	5	2	9.97	6.20	21.84	27.75	30.11	28.87
	14	172	127	226	217	16	12	2	4	6.64	7.08	25.91	17.94	34.04	30.65
	15	278	310	382	353	19	16	4	3	10.64	11.66	26.13	26.59	35.90	30.27
	16	171	143	195	178	17	14	3	2	7.61	5.93	22.47	24.11	25.62	30.02
M6	8	101	111	231	277	17	15	2	5	7.83	7.20	12.90	15.42	29.50	38.47
Phase	9	182	178	333	306	16	17	2	4	9.20	7.75	19.78	22.97	36.20	39.48
III	10	152	161	262	306	23	10	2	4	8.32	8.70	18.27	18.51	31.49	35.17
	11	172	169	300	185	18	15	5	2	10.84	6.43	15.87	26.28	27.68	28.77
	12	167	132	422	109	19	14	2	4	8.81	4.96	18.96	26.61	18.96	21.98
	13	209	276	439	407	14	20	4	2	11.71	9.93	17.85	27.79	37.49	40.99

Phase IV	10	199	149	667	51	28	6	5	0	16.60	2.66	11.99	56.02	40.18	19.17
	11	332	103	786	57	19	17	5	4	19.00	3.29	17.47	31.31	41.36	17.32
	12	164	93	254	38	21	9	5	3	13.33	4.45	12.30	20.90	19.05	8.54
	13	198	106	348	45	23	11	4	3	12.98	3.86	15.25	27.46	26.81	11.66
	14	250	104	387	64	25	10	5	2	11.77	3.50	21.24	29.71	32.88	18.29
	15	337	141	520	62	27	8	5	3	12.64	3.50	26.66	40.29	41.13	17.71
Phase V	8	229	384	202	305	18	15	2	3	7.83	12.55	29.25	30.60	25.80	24.30
	9	236	262	251	163	17	12	2	3	9.14	6.45	25.82	40.62	27.46	25.27
	10	226	165	124	105	15	16	3	2	6.34	4.58	35.65	36.03	19.56	22.93
	11	257	279	281	313	21	14	3	3	11.12	13.76	23.11	20.28	25.27	22.75
	12	151	121	123	83	13	13	3	4	5.60	4.00	26.96	30.25	21.96	20.75
	13	151	146	105	127	15	13	2	3	4.52	5.60	33.41	26.07	23.23	22.68
M9 Phase III	8	466	516	195	195	16	12	13	11	8.63	8.87	54.00	58.17	22.60	21.98
	9	636	641	211	175	19	16	13	11	9.67	8.77	65.77	73.09	21.82	19.95
	10	495	623	180	177	20	12	11	13	8.36	9.04	59.21	68.92	21.53	19.58
	11	748	728	190	216	17	14	13	11	9.01	9.94	83.02	73.24	21.00	21.73
	12	716	636	265	279	14	16	10	14	9.62	10.12	74.43	62.85	27.55	27.57
	13	644	598	240	189	14	15	11	13	8.94	8.40	72.04	71.19	26.85	22.50
Phase IV	31	429	110	1072	57	35	4	6	3	19.92	2.91	21.54	37.80	53.82	19.59
	32	293	176	711	46	26	11	3	4	12.15	2.58	24.12	68.22	58.52	17.83
	33	269	187	533	47	23	10	4	3	11.40	2.23	23.60	83.86	46.75	21.08
	34	302	260	569	60	29	12	7	4	17.50	7.15	17.26	36.36	32.51	8.39
	35	526	180	779	62	34	7	6	2	19.55	3.86	26.91	46.63	39.85	16.06
	36	324	184	422	44	26	8	7	4	12.31	2.38	26.32	77.31	34.28	18.49
Phase V	9	359	206	268	263	15	16	4	3	8.05	6.15	44.35	33.50	33.26	42.76
	10	338	404	303	386	14	18	3	3	7.58	10.05	44.59	40.20	39.97	38.41
	11	324	374	341	470	18	16	2	3	7.50	9.87	43.20	37.89	47.36	47.12
	12	495	402	458	444	18	18	5	3	11.72	11.50	42.24	34.96	39.08	38.61
	13	431	353	294	451	17	14	2	4	8.66	10.95	49.77	32.24	33.95	41.19
	14	281	257	183	189	14	14	4	3	5.66	5.58	49.65	46.06	32.33	33.87

M10	10	430	333	92	114	17	13	3	2	8.96	8.55	47.99	38.95	10.27	13.33
Phase	11	518	311	128	106	15	14	2	4	9.42	7.66	54.99	40.60	13.59	13.84
III	12	306	212	77	50	14	13	5	2	7.26	4.08	42.15	51.96	10.61	12.25
	13	304	370	100	100	16	15	2	4	6.79	6.91	44.77	59.39	14.73	14.47
	14	375	280	143	85	18	13	4	2	9.55	6.23	39.27	44.94	14.97	13.64
	15	272	282	117	107	16	13	3	3	6.28	5.20	43.31	54.23	18.63	20.58
Phase	28	194	218	143	45	20	12	3	4	7.70	4.18	25.19	52.15	18.57	10.77
IV	29	374	125	271	45	28	0	5	5	15.26	2.85	24.51	44.48	17.76	15.79
	30	444	209	308	32	22	16	4	4	11.83	2.81	37.53	74.38	26.04	11.39
	31	460	153	550	59	31	6	8	1	18.72	2.65	24.57	57.74	29.38	22.26
	32	448	203	386	49	29	8	6	2	17.80	3.30	25.17	61.52	21.69	14.85
	33	193	232	193	39	13	16	6	4	7.75	3.05	24.90	76.07	24.90	12.79
Phase	8	452	446	261	238	18	17	3	2	9.76	8.15	46.31	54.72	26.74	29.20
V	9	293	306	119	122	17	12	4	3	6.03	4.99	48.59	61.32	19.73	24.45
	10	345	451	197	276	15	13	3	5	6.56	8.63	52.59	52.26	30.03	31.98
	11	170	353	172	176	16	14	3	2	6.28	6.85	27.07	51.53	27.39	25.69
	12	361	486	136	242	15	17	3	3	6.00	8.56	60.17	56.78	22.67	28.27
	13	298	302	132	176	14	15	2	4	5.37	6.00	24.58	50.33	24.38	29.33